AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Bulletin No. 88 EMERGENCY BULLETIN April, 1917

FIELD CROPS FOR LATE PLANTING

By

C. S. KNIGHT, B.S.,
Dean of the College of Agriculture, and Agronomist of the
Agricultural Experiment Station

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1917

1[85]

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. JAMES F. ABEL (1917–1921), Chairman	Reno
Hon. JAMES W. O'BRIEN (1915–1919)	Sparks
Hon. JOHN J. SULLIVAN (1915–1919)	Reno
Hon. B. F. CURLER (1917–1921)	Elko
Mrs. EDNA C. BAKER (1917–1919)	Sparks

OFFICERS

ROBERT LEWERS	Acting President of the University
GEORGE H. TAYLOR	Secretary
CHARLES H. GORMAN	Comptroller

STAFF

SAMUEL B. DOTEN, M.A.	Director and Entomologist
WINFRED B. MACK, D.V.M.	Bacteriologist and Veterinarian
JAMES EDWARD CHURCH, JR., Ph.D.	Meteorologist
C. ALFRED JACOBSON, Ph.D.	Chemist
CHARLES S. KNIGHT, B.S.	Agronomist
CHARLES E. FLEMING, B.S.A.	Range Management
EDWARD RECORDS, V.M.D.	Assistant Bacteriologist
STEPHEN LOCKETT, V.M.D.	Assistant Veterinarian
HARRY W. JAKEMAN, V.M.D.	Assistant Bacteriologist
MAXWELL ADAMS, Ph.D.	Consulting Chemist
PETER FRANDSEN, A.M.	Consulting Biologist
PHILIP A. LEHENBAUER, Ph.D.	Consulting Botanist and Horticulturist
FREDERICK W. WILSON, M.A.	Consulting Animal Husbandman
VERNER E. SCOTT, B.S.	Consulting Dairy Husbandman
JOHN BLAIR MENARDI, B.S.	Assistant in Agronomy
Mrs. T. W. COWGILL	Librarian
RUTH A. PYLE	Secretary

April 24, 1917.

GOVERNOR E. D. BOYLE, *Carson City, Nevada.*

SIR: For some years past the Nevada Experiment Station has been conducting a series of experiments known as Projects 1 and 2, Hatch Fund. Project 1 is a series of irrigation experiments intended to show the stages at which water is most greatly needed by the principal crops grown in Nevada. Project 2—Variety Testing and Crop Improvement—was planned to discover the best varieties of those crops which are best suited to Nevada conditions. From these experiments a very considerable amount of information has been obtained.

In the present emergency it has been become highly important to publish in popular form a part of this information in the hope that it may be immediately useful. Later all the results of the experiments will be published in full detail as a complete bulletin covering the work done upon these projects.

Respectfully, S. B. DOTEN,
Director.

FIELD CROPS FOR LATE PLANTING

On account of the late cold spring, the preparation of land for planting has been delayed several weeks. In many agricultural districts of the State considerable acreage, originally planned to be planted to wheat or barley for grain, cannot be prepared in time for these crops and must, necessarily, be used for some late-planted crops. The present national crisis calls for the cropping of all possible acreage in the State of Nevada.

Where land can be prepared for planting in the early part of May, the cereals can be grown with very good results, although the yield per acre may be less than with grain planted at an earlier date. Land that is not ready for planting until the last of May or early part of June will produce heavy yields of the late-planted crops, most of which are sown after the danger of late frosts has passed. Wheat and oats (for hay), potatoes, sugar-beets, Sudan grass and millet are the important crops recommended for late planting in Nevada.

PREPARATION OF LAND

Plowing: Since most of the crops above mentioned may be planted as late as the early part of June, several weeks still remain in which to prepare large areas for cropping in the agricultural districts of Nevada.

Late spring sowing should generally not be over 6 inches deep, since, with the deeper plowing, too short a time remains to prepare a firm seed-bed and insure a uniform germination of the seed. When the ground is plowed early in the spring or the previous fall, the depth may be increased 2 or 3 inches, since plenty of time remains for the seed-bed to become sufficiently firm for planting.

DISKING

As fast as the ground is plowed it should be thoroughly pulverized with the disk harrow. This implement is very effective in pulverizing the clods and at the same time packing the subsoil. With late plowing it is sometimes advisable to give the ground two or three extra workings with the disk harrow, so that the land will be firm enough for planting in a few days. If a roller or roller-pulverizer is available, the packing of the soil will be accomplished more quickly and efficiently.

HARROWING

As soon as the ground has been thoroughly disked, follow with a smoothing or spike-tooth harrow to prepare a coarse loose mulch on the surface. This mulch prevents rapid evaporation from the soil and at the same time holds the moisture near the surface for the germination of the seed.

LEVELING

Often the land requires some leveling after plowing before it is ready to plant. In such instances a leveler or smoother may be used after the disk harrow to properly level the land for irrigation. An efficient leveler is easily constructed on the farm. This may consist of two 2-inch planks 10 inches wide and 18 feet long with four 2-inch cross planks 10 inches wide and about 9 feet long. This will provide a leveler 9x18 feet. Inch boards may be used for braces and to provide a foot-walk for the driver.

Iron hooks should be bolted to the front end of the 18-foot planks for the attachment of the draft.

WHEAT AND OATS AS HAY CROPS

Wheat or oats planted as late as June 1 will produce excellent hay crops, as sufficient time still remains for these grains to reach the milk stage of growth. At this stage the crop has stored the greater part of the food elements of matured plants, although considerable of this food is still held in the stems. The grain should be cut for hay before it reaches the dough stage, otherwise the stems get too coarse and are not relished by the stock. After cutting, the grain hay is cured and stacked in the same manner as timothy. When these crops are grown for hay, about 90 pounds of wheat and 100 pounds of oat seed should be sown per acre.

POTATOES

The present high price of seed and the shortage of potatoes is the important difficulty confronting the Nevada potato-grower this spring.

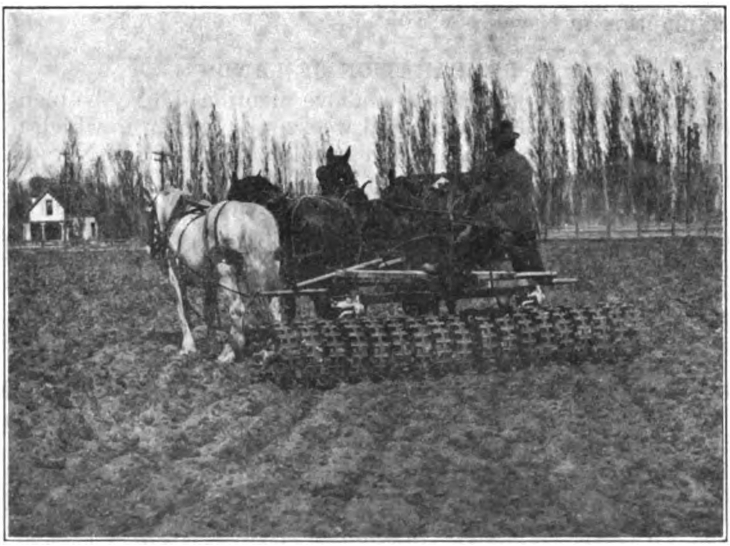


PLATE No. 1—A roller-pulverizer, a very efficient implement for packing the soil and breaking clods in preparing land quickly for late-planted crops.

It is, therefore, very necessary that the available potato seed cover the greatest possible acreage and result in the maximum production. An important factor is the treatment of the seed for the prevention of scab and other diseases. The following treatment is recommended: All seed potatoes should be soaked in a solution of mercury bichloride (corrosive sublimate), 4 ounces in 30 gallons of water, for one and one-half hours. Formalin treatment will not kill *Rhizoctonia* as completely as mercury bichloride. The solution should be placed in a wooden barrel or tank. It corrodes metal. It should be poured out and made up fresh after it has been used to disinfect four lots of potatoes. It is poison to eat, but

not to the touch. Treated potatoes should not be eaten or fed. After the potatoes have been treated, they should be stored in new sacks which have been similarly disinfected in the solution.

This year the entire country is experiencing a considerable shortage in potato seed; thus, all available potatoes will be planted, regardless of variety. The Experiment Station has tested a number of varieties during the past four years, ranking in yielding power in the order named: Great Divide, Burbank, Early Ohio, Peerless, Early Russett, Irish Cobbler, Carman No. 3, Early Red, Netted Gem, Rural New Yorker, Gold Coin. Great Divide and Burbank varieties showed the highest average yield for the four-year period. These two varieties have been grown in Nevada for many years and indicate the value of well-selected home-grown seed as compared with that introduced from the other States. The Peerless and Netted Gem varieties are grown to some extent in the potato districts of Nevada.

Another important factor is the cutting of the large potatoes into small pieces to increase the acreage to the greatest possible extent.

PLATE No. 2—Irrigating potatoes on the Barrett Ranch in Mason, Nevada.

Cutting the Seed.

The potatoes should not be cut in pieces less than 1 ounce in size, and the best crops will be obtained where the pieces are from 1½ to 2 ounces. The seed piece should be large enough to give the plant a good start. Each piece should have two good eyes. Where more than this number of eyes is present and also with pieces 2 ounces or more in weight, the soil must be very fertile and the seed pieces planted farther apart in the rows, otherwise the percentage of small tubers may be too great.

A good method to follow in cutting the seed is to begin cutting from the stem end, diagonally across the potato, being careful to cut the seed end so that too many eyes are not left on one piece.

Rate of Seeding.

Where one-ounce seed pieces are used, the potatoes should be planted in rows 3 feet apart and about 15 inches apart in the row. With two-ounce seed pieces the distance apart in the row may be 18 inches.

The amount of seed required per acre with different sized seed pieces is shown in the following table:

Weight, ounces	*Pounds of seed 15 inches between hills*
1.0	720
1.5	1,080
2.0	1,440

Planting.

In most parts of Nevada the late potatoes are planted between May 1 and 20, usually about 4 or 5 inches deep, on land spaded or plowed at least 8 inches deep before the 1st of May.

On small tracts a common method of planting is to plow the land shallow and drop the seed in every third furrow, but on the larger areas the machine planters are recommended.

Irrigation.

The potato rows should be hilled up with good deep furrows between them, so that, when irrigated, the water will supply the deep-feeding roots, but will not come in contact with the tubers.

A too common error with the potato-grower is the use of shallow furrows for carrying the water. The chief danger is in saturating the ground around the tubers, causing the soil to become hard and compact, a very undesirable condition for the development of a good hill of uniform potatoes. It is thus very important to use light irrigations in good deep furrows.

In the irrigation experiment with potatoes conducted at the Experiment Station, the results of the test for the first three years favor the 3-inch irrigations as compared with 6- and 9-inch applications. The most practical results were obtained with six 3-inch irrigations, or a total of 18 inches of water, given when the plants showed a tendency to wilt.

In the irrigation of potatoes, the best results were obtained when the first irrigation was withheld until the plants turned a darker green color, but had not wilted. This condition permitted the greatest possible root development to supply the necessary food for a maximum crop. Early irrigation, before the plants showed any need of water, greatly retarded the proper development of root system and resulted in a decreased yield of potatoes.

After irrigation had started, it was found very essential never to allow the plants to suffer for lack of water during the growing season. Where any plants wilted slightly after irrigation commenced, the growth of the plant was greatly checked, and the yield and quality of tubers were seriously affected.

Cultivation.

Cultivation should be given after each irrigation until the plants are so large as to be injured by the horse or cultivator. Cultivation is just as important as irrigation for success in potato culture, since it thoroughly aerates the soil, keeps down the weeds, helps to retain moisture in the soil and maintains a good deep furrow for irrigation. The soil should be kept in a moist condition until the potatoes are fully grown. In most of the potato districts of Nevada, irrigation will generally cease from August 15 to 31, varying with the season and time of planting.

SUGAR-BEETS

In western Nevada, where the distances from the factory are not too great, the sugar-beet can be planted as late as June 1 with good results. The Nevada-Utah Sugar Company at Fallon will contract with the farmers for the growing of beets for the factory, paying as high as $7 per ton for beets grown in western Nevada. The company also contracts for all hand labor required, thus eliminating the important objection to beet-growing in this State. The following table gives the results of an investigation at the Experiment Station on the date of planting sugar-beets:

PLANTING SUGAR-BEETS

Date of planting	*Yield per acre, tons*
April 16	15.29
April 23	20.79
April 30	20.35
May 7	17.22
May 14	16.17
May 21	18.42
May 28	14.96
June 4	12.54
June 11	11.00
June 18	9.90
June 25	8.91
July 2	4.79

The results of this experiment indicate that beets planted from April 20 to May 20 will produce the heaviest yields. This particular season included a rather cold wet spring, which may be responsible for the relatively low yield of 15.29 tons per acre with beets planted on April 15. The maximum production of 20.79 tons per acre was received from beets planted on April 23. These results indicate the importance of having all beets planted before the 1st of June, since after that date a decrease in yield from 12.54 tons to 4.79 tons per acre occurred, the latter yield representing beets planted on July 2.

It is a general practice in Nevada to sow sugar-beet seed as soon as the conditions will permit, so that the plants can secure a good start before hot weather approaches and mature before it becomes too cold. This also gives the grower an opportunity of reseeding if the first crop becomes damaged or destroyed. However, with a backward spring, the best results will probably be obtained by seeding between the 20th of April and the 20th of May. This experiment will be repeated in 1917.

Sugar-beet seed can be secured from the Nevada-Utah Sugar Company at Fallon. The amount of seed to sow will vary, with the locality, kind of soil and vitality of seed, from 10 pounds to 25 pounds per acre. On the light soils, light seeding is employed, but on the clay loams and clay soils from 18 pounds to 25 pounds are usually sown per acre. The average amount sown in the beet sections of this State is from 15 pounds to 20 pounds per acre.

The seed is usually sown by the ordinary four-row force-feed beet drill, with shoe furrow openers. This implement will plant from 10 to 12 acres per day. When a large area of land is to be planted to beets, the seeding should not be continuous, since it may be impossible to complete the process of thinning before some of the beets become too large. Several days should elapse between sowings, so that the thinning may be done at the proper stage of growth.

The distance between rows may vary to quite an extent with the

locality, but in the beet sections of this State from 18 to 20 inches is the most desirable distance, This spacing is wide enough to permit cultivation of the beets and the furrowing for irrigation. The rows should be run with the greatest slope of the field and as straight as possible. When beets are planted too far apart the roots will grow too large, the development of the top will be too large compared with the root, the yield smaller, the sugar-content and purity lower, and the conservation of moisture less than with close planting.

The depth of seeding usually varies from 1 to 2 inches with the character and condition of the soil. In the heavier soils it is seldom necessary to plant the seed more than 1 inch deep. In the light sandy soils deeper planting is practiced. The drills are often arranged with press-wheels, which follow along behind the shoes, firming the soil on either side of the seed, but leaving loose dirt directly over the seed. Furrowing shovels may also be attached for making the small furrows between the rows.

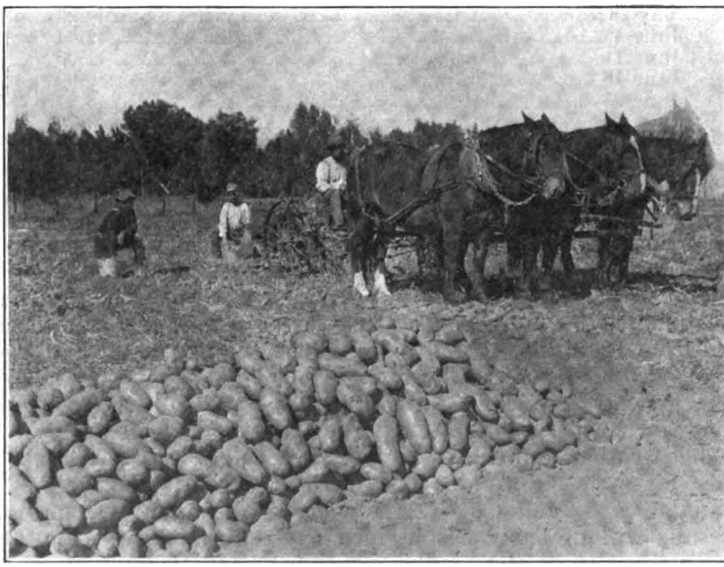


PLATE No. 3—Harvesting potatoes on the Truckee Meadows. A very desirable market potato.

Thinning.

This is undoubtedly the most tedious process in the culture of sugar-beets, and one which should receive the most careful attention. The thinning should commence as soon as most of the beets have formed four leaves, and the work should be completed in a week's time. After this period the roots become entangled and make the process a difficult one without injuring the root of the remaining plant.

An ordinary short-handled five-inch hoe is used for cutting out from 5 to 7 inches of beets and leaving about a 2-inch space with from 3 to 5 plants. The strongest plant in the bunch is selected, and the others pulled out with the roots by the free hand of the laborer. If the leaves are removed and the roots remain, they will continue to grow. All surrounding weeds should also be pulled by the thinner. This leaves a

healthy beet every 8 or 10 inches in the row. In Nevada this work is performed chiefly by Japanese labor. The Indians are becoming better acquainted with this process and are being used more extensively for the hand labor in connection with the growing of the crop. The beets will probably have a wilted appearance after thinning, and if this condition remains for a couple of days they should have a light rolling to pack the moist soil around the roots to revive them. An experienced man can thin from one-half to three-fourths of an acre per day, but one-third of an acre is about the limit of the average man.

Cultivation.

Cultivation is necessary to remove weeds and loosen the ground, so that the crop may get the full benefit from the sun, and the moisture be retained in the soil. When the ground is irrigated after sowing to germinate the seed, cultivation is necessary to break any crust which has formed on the surface. This is best accomplished by the use of the beet

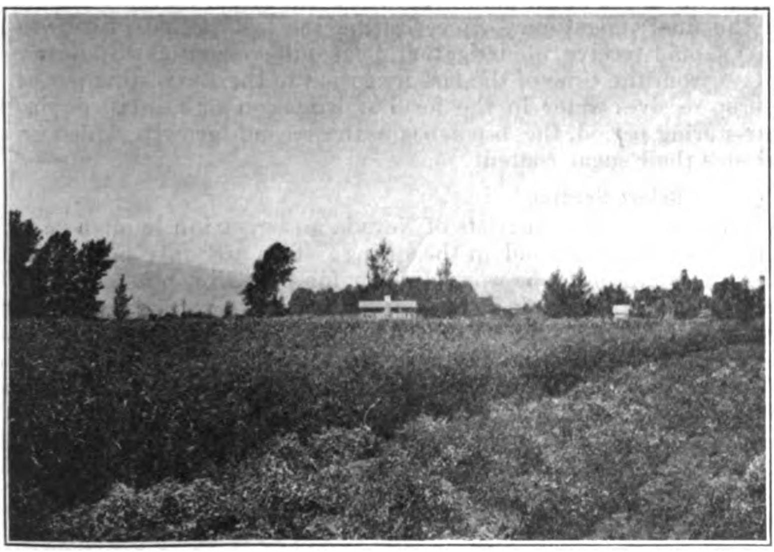


PLATE No. 4—Sudan grass in the background, field peas in the foreground. Both crops do especially well in Nevada.

cultivator with the weeding-knives and duck-feet or deer-tongues attached. With these attachments any weed growth between the rows is destroyed and the surface soil is loosened without any disturbance to the small beet-plants. Where the soil is lumpy, the use of shields will prevent any injury to the young plants. In many cases where the ground is not too wet, the roller may be used to advantage in breaking the crust and mashing the lumps, besides packing the soil around the plants and increasing the flow of water up to the plants. When the roller is used for this purpose it should be followed as soon as possible by the cultivator in order to loosen the surface soil and prevent too rapid loss of water by evaporation.

The cultivation should begin as soon as the young plants begin to appear in the rows, if all the weeds are to be destroyed. It is then

possible to kill most of them before they become well rooted. The knives and duck-foot are implements commonly used. They cover from 10 to 15 inches between the rows, leaving a space of about 3 inches next to the rows, which prevents clods from rolling onto the plants. After thinning the beets the ground is packed more or less by the thinners and cultivation is necessary. Frequently this is the first cultivation the crop receives. A few days after this cultivation the crop should be given the second hoeing to remove all weeds not killed by the cultivator and to loosen the soil close to the beets. After the second hoeing the beets should be given the second cultivation, using the deer-tongue instead of knives and going deeper than the previous cultivation. To keep the surface soil loose around the beets and conserve the moisture in the soil, the beets should receive a third hoeing and frequent cultivation at intervals of from 10 to 12 days, until the plants have developed large leaves and are ready to lay by. The depth of cultivation should be increased as the plant grows larger. As a rule all cultivation ceases after 85 to 95 days from the time of planting, except the last deep horse cultivation and the final irrigation. Since during the last period of growth the plants should receive no irrigation, it is quite essential to allow 20 or 30 days from the time of the last irrigation to the harvesting period. If the crop receives water in the form of irrigation or rainfall during the sugar-storing period, the beets begin the second growth, which greatly decreases their sugar-content.

Irrigation Before Seeding.

In most of the beet districts of Nevada an irrigation is often necessary before plowing the ground in the spring. This not only puts the soil in excellent condition to be worked down for planting, but also starts the growth of any weed seeds in the top soil, which is later turned under in plowing. This may supply sufficient moisture to germinate the seed and give the plants a good start, but a safe plan is to mark out the furrows at the time of planting, so that water may be applied at any time after planting if the condition of the ground or crop indicates a shortage of moisture. The best stands of beets have been secured by irrigating immediately after planting, and where land has been properly leveled, so that water cannot get out of the furrows onto the beets, no injurious effects have been noticed from this practice.

WHEN TO IRRIGATE SUGAR-BEETS

In most sections of this State, in the clay loam and loam soils, from two to four irrigations are usually sufficient. The quality of the soil, the location of the field, the slope of the land, the subsoil, the rainfall, and temperature of the atmosphere during the growing season are factors which will influence the time and number of irrigations. When the soil contains sufficient moisture to germinate the crop, the first application of water should be withheld as long as possible, so that the roots will penetrate the soil to considerable depth for moisture. After the first irrigation a damp soil is required. If the soil becomes too dry, the growth will cease, and the root becomes soft and spongy. When this stage is reached and water is applied, a second growth sets in, usually resulting in the production of beets with a low sugar-content and poor quality. The aim should be to keep the ground damp and cultivate frequently to keep the moisture near the plants. During hot days the evaporation

from the leaves of the beet is great, and they may wilt. This is no sign that the plants require another irrigation, for the soil may contain sufficient moisture, but it could not be supplied by the roots as fast as it was being evaporated from the leaves. It will generally be found that at night when, the evaporation has greatly decreased, the plants assume their normal condition. If, however, when examined in the early morning the plants appear wilted for one or two days, the soil will be found lacking in available moisture, and an application of water is necessary. There is no definite rule as to when to stop irrigating, but it should cease when the beets commence to turn yellow and begin to ripen.

Method of Irrigating Sugar-Beets.

The important methods used in the irrigation of sugar-beets in Nevada are furrowing and bordering. In most of the beet sections of this State the method of furrowing will undoubtedly give the best results, since irrigation is absolutely essential during the period of growth. The initial cost of this method and the cost of maintenance is small; the water can be easily applied and kept from the plants, thus preventing the soil from baking around them. A loose mulch of soil is kept around the plant, and by cultivation in the furrows after irrigation a relatively small amount of water is lost by evaporation. The furrow method does not interfere with the work of planting, cultivating, and harvesting of the beets, as in the case with checks and borders.

Production and Profit.

From the fact that sugar-beet growing is a new industry in Nevada there has been considerable variation in the production per acre. The average yield per acre for this crop in the beet districts will not exceed 12 tons, but this should not be taken as a basis for figuring returns, as it represents both good and poor farming methods. Where the proper methods of culture have been carefully followed, the average yield per acre has varied from 15 to 20 tons.

The total cost of growing a beet crop varies greatly, depending upon the amount of work required in the preparation of the ground for planting, and whether or not the weeds are kept under control by cultivation and hoeing. It averages from $30 to $45 per acre, while the average profits range from $30 to $50 per acre. In the Fallon district profits of over $75 per acre have been recorded.

For further information on beet-growing in Nevada, address Department of Agronomy, University of Nevada, Reno, Nevada.

SUDAN GRASS

Sudan grass is an annual forage crop somewhat resembling millet in habit of growth. It attains a height of from 5 to 6 feet, produces an abundance of forage, and is also a valuable seed crop. In the 1916 experiment it produced 3.8 tons of forage, and 1,912 pounds of seed per acre. These results indicated that the crop was much more valuable for seed than forage. It is not a difficult crop to grow in Nevada for either seed or forage. Sudan grass seed is selling on the market this year at from $32 to $40 per hundred pounds. This high price is due to the small amount of seed produced annually and the great demand for the same. Since the crop is easily grown and seeds so abundantly, the tendency will be for the price of seed to gradually decrease as the acreage of this crop increases.

Sudan grass will grow on all well-drained soils of Nevada, although, like most other crops, it produces the best results on the fertile loam soils. When planted in rows and given continuous cultivation this crop will withstand considerable drought. The planting must be delayed until the danger of late spring killing frosts has passed. At the Experiment Station the practice has been to sow from the 15th to the 25th of May. If the crop is to be grown for forage, the seed may be broadcasted or sown with a grain-drill not over $1\frac{1}{2}$ inches deep at the rate of about 20 pounds per acre. When grown for seed the planting should be done in rows, about 30 inches apart, and from 5 to 6 pounds of seed per acre will be sufficient. The seed-bed should be prepared the same as for alfalfa and, if grown in rows, the soil kept in a loose mellow condition by cultivation.

In most agricultural sections of Nevada, as at the Experiment Station, only one crop of hay is possible, and the crop is best cut when in full bloom. The hay crop is harvested in a similar manner to alfalfa, but when the crop is raised for seed it should be harvested with a binder and shocked as with wheat or barley. By harvesting our seed crop when the first heads were fully ripe, practically no loss of seed was encountered by shattering. The seed crop was threshed with the same machine used for wheat and barley.

The chief value of Sudan grass as a hay crop in Nevada will be in the dairy districts where alfalfa is the only feed used. The Sudan grass is relatively low in protein and may largely counteract the digestive troubles of the cows that have been fed continuously on the high-protein alfalfa hay. Sudan grass, like most annual crops, does not make a desirable pasture, as it does not form a sod and is greatly injured by tramping. This crop has not been used for pasture at the Experiment Station, but it is claimed that, being a sorghum, there is danger of poison to stock from the prussic acid contained in the immature plants.

MILLET

The millets do not grow well until the hot weather approaches, but if planted in June or July they will make a hay crop in from 8 to 10 weeks. They are decidedly drought-resistant crops and will grow well in regions of slight rainfall. Millet does better on sandy loams than on the heavy clays. Since the seed is small, the ground should receive about the same preparation as when fitted for seeding to alfalfa. The plant has abundant feeding roots and will grow fairly well on poor soil. The same method of seeding may be used as for alfalfa. Twenty-five pounds of good seed to the acre is sufficient, but with inferior seed twice this amount may be required.

The crop will be ready to cut for hay in from 8 to 10 weeks after seeding, and should be cut about the time the plants begin to bloom. If seed is allowed to form, the hay is not as palatable to stock, and may be actually injurious to horses. When grown for seed production, the crop should be cut before it is thoroughly ripe, to prevent loss from shattering. It may be harvested with a grain binder and shocked and threshed like the grain. Twenty bushels of seed per acre is a good yield in Nevada.

The Common or Foxtail millet, the earliest maturing variety, is probably the best for hay and pasture. The hay should, however, be fed with alfalfa or some other hay. If fed in quantity, especially to horses,

it is likely to cause serious disorders of the kidneys. The seed is seldom used for feeding except to poultry, although it may be ground and fed with good results to hogs, cattle, and sheep.

The following table includes the results of investigations by the Experiment Station during the past three years in the production of Sudan grass and millets for forage:

Variety	*Yield per acre of forage (pounds)* 1914	1915	1916	Average
Sudan grass	....	2,656	7,586	5,121
Millet, Siberian	6,595	3,547	6,149	5,430
Millet, Hog	....	4,251	6,168	5,210
Millet, Kurch	....	4,076	6,227	5,147
Millet, Common	....	6,427	5,135	4,881
Millet, Colorado Golden	5,546	2,237	4,581	4,121
Millet, Early Fortune	4,693	2,389	4,907	3,996
Millet, Hungarian	....	2,649	4,744	3,697

PLATE No. 5—A test of millet varieties, showing the growth that is possible with this crop in Nevada.

In this experiment the Sudan grass and millets were planted from May 15 to May 25, in rows 30 inches apart, and about 1 inch deep. In 1916 Sudan grass produced 3.79 tons per acre, while the average for the two years was 2.5 tons per acre. In the 1916 results all millet varieties were surpassed by Sudan grass in production of forage, while for the two- and three-year averages the Siberian, Hog, and Kurch varieties showed an increased yield. The Siberian is a variety of Foxtail millet. For further information on these crops, address Department of Agronomy, University of Nevada.

O

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

BULLETIN No. 89 --OCTOBER, 1917

Grain Production in Nevada

BY

C. S. KNIGHT, B. S.

DEAN OF THE COLLEGE OF AGRICULTURE AND AGRONOMIST
OF AGRICULTURAL EXPERIMENT STATION

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

NEVADA AGRICULTURAL EXPERIMENT STATION

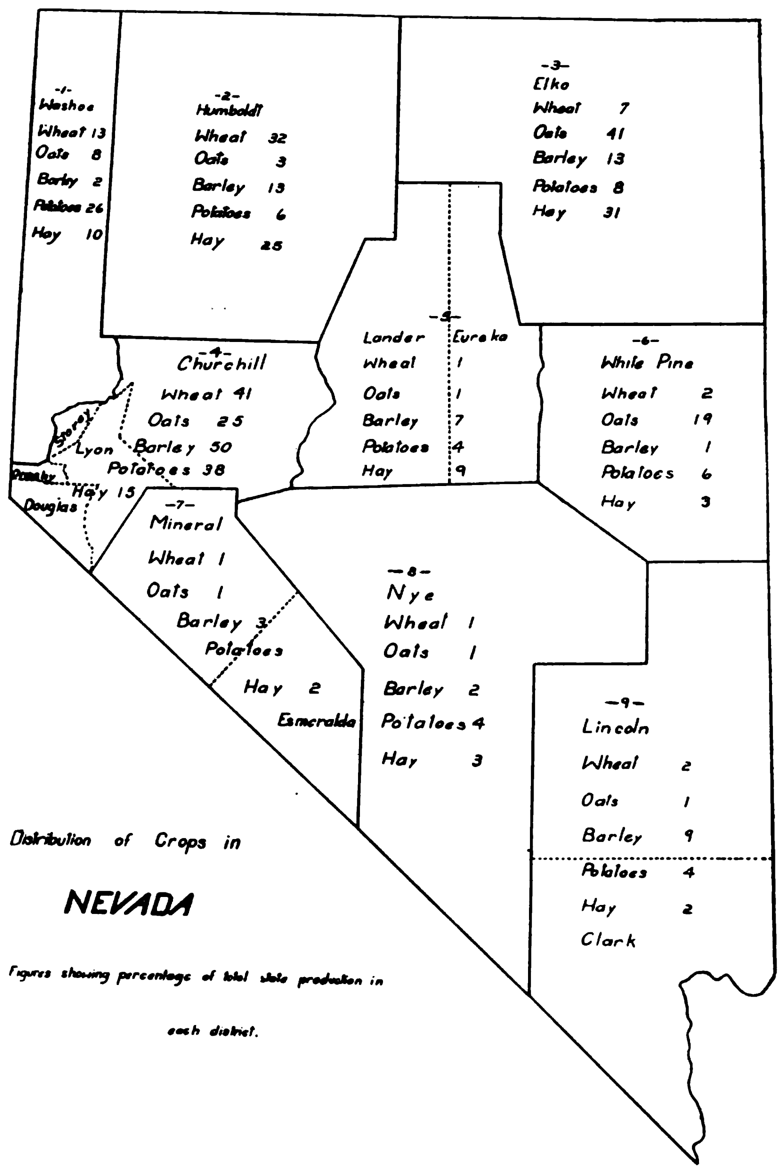
BOARD OF CONTROL

OFFICERS

STAFF

TABLE OF CONTENTS

	Page
THE CEREALS, Introduction	5
WHEAT	5
Types of Wheat Grown in Nevada	5
Common Wheat	5
Club Wheat	6
Durum Wheat	7
Investigations with Wheat Varieties	7
Wheat Soils	10
Alkali Soils	11
Kinds of Alkali	11
How Alkali Affects the Wheat Plant	11
Reclaiming Alkali Land	12
Amount of Alkali Wheat Can Withstand	12
Growth of the Wheat Plant	12
Cultural Methods	13
Preparing Sagebrush Land for Wheat	13
Plowing	14
Preparing the Seed Bed	16
Seeding	16
Treatment of Wheat for Smut	17
Test Seed for Germination Before Planting	18
Cultivation	18
Summer Fallowing in the Dry Farming Districts	19
Irrigation of Wheat	20
Methods of Irrigation	20
Flooding from Field Ditches	20
Border Method	21
Flooding in Checks	22
Furrow Irrigation	22
Amount and Time of Irrigation	23
Irrigation Investigations with Wheat	25
Comparing Three-inch and Seven-inch Irrigations	25
Results with One Irrigation Omitted	25
Results with Two Irrigations Omitted	26
Harvesting and Threshing	26
BARLEY	28
Investigations with Barley Varieties	29
Soil	30
Cultural Methods	30
OATS	31
Investigations with Oat Varieties	31
Soil	33
Cultural Methods	33
CO-OPERATIVE VARIETY TESTS WITH WHEAT AND BARLEY	34



Map of the State of Nevada, showing production by districts in percentage

Grain Production In Nevada

CHAS. S. KNIGHT
Dean of the College of Agriculture and Agronomist in the Experiment Station

THE CEREALS

Of the cereals wheat oats and barley are the chief crops grown, altho a small acreage of rye is planted each year on new land that will not produce a good crop of any other cereal. The rye plant has a very hardy root system which makes it better adapted to the new lands that are very low in nitrogen and humus. Furthermore it will do better on the light soils, and usually produce a fair crop the first year.

WHEAT

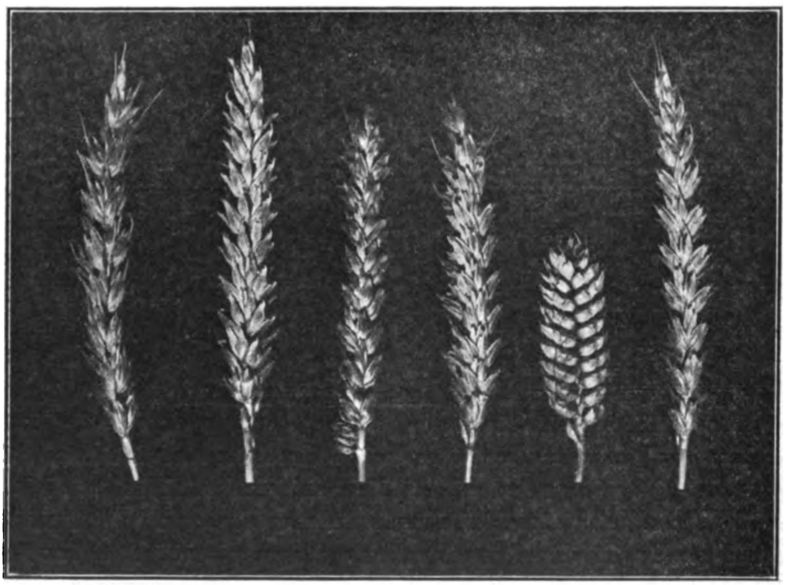
In 1916 about 60,000 acres of wheat were raised in Nevada, one-third of which was produced in Humboldt County, and over 80 per cent in Humboldt, Washoe, Churchill, Lyon and Douglas Counties. Practically all of the wheat raised in Nevada is sold for milling purposes, thus it is very important to produce a wheat of high milling quality which will command the top price, as well as one capable of heavy production. No one variety has been found best suited to all of the wheat sections of the State. The yield and quality of the wheat vary greatly with the amount of water supplied to the crop. This may be the result of excessive irrigation or too much water supplied from a high water table. When either of these conditions occur the wheat kernels will be soft and have a poor milling quality. However, on well drained lands and by a conservative use of water, it is possible to produce the maximum yield of wheat of excellent quality for milling. Such has been the experience at the Experiment Station even with the hard spring variety of Marquis wheat. However, where Marquis wheat has grown on poorly drained land with a high water table or on well-drained land where excesive irrigations were given, neither the yield nor quality of the wheat equaled the common White Club variety in these respects. Marquis wheat was grown at the Experiment Station under irrigation for a period of four years with no decrease in the milling quality of the wheat from year to year, when the crop received less than 30 inches of water with seven inches or less at each application.

TYPES OF WHEAT GROWN IN NEVADA

COMMON WHEAT. This is the type commonly grown throughout the agricultural sections of Nevada due to its high yielding power and its excellency for bread making. Both winter and spring varieties

are grown, the winter varieties being confined chiefly to the dry farming areas. Most of the spring varieties grown in Nevada are of the beardless type.

Turkey Red and Gold Coin are the varieties of winter wheat commonly grown in Nevada. Turkey Red, a hard red wheat, is grown chiefly in the dry farming regions while Gold Coin, a medium hard or soft white wheat, is confined principally to the irrigated sections.



Wheat from left to right

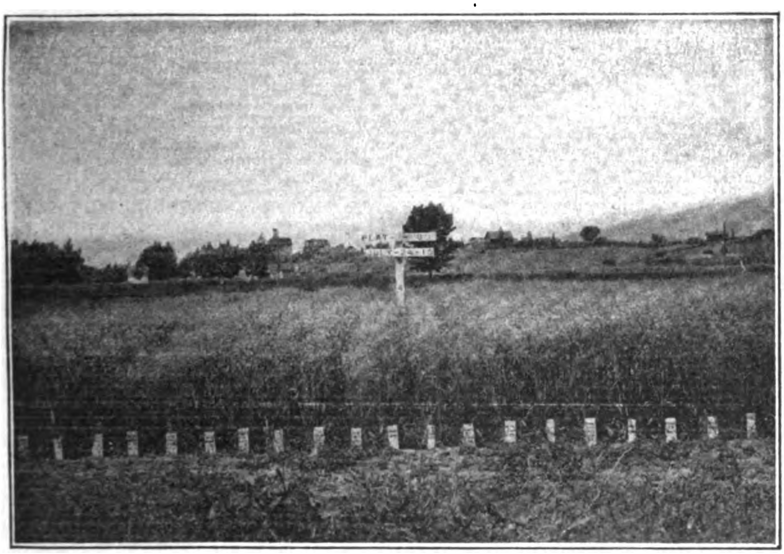
1. Colorado No. 50 (Wyo.)
2. Defiance (Colo.)
3. Bluestem (Wash.)
4. New Zealand (Colo.)
5. White Club (Utah)
6. Marquis (Nev.)

The winter varieties should be planted in the fall and the growth of plant started before the ground freezes. When winter wheat is planted in the spring by mistake, the plants will simply stool out, spread leaves over the surface and wait until the next summer before maturing a crop of grain, the use of the ground being lost for one year.

Club Wheat. This type is sometimes called Hedgehog or Dwarf wheat. It is characterized by a short compact club-shaped head and a short stiff straw, and may be bearded or beardless. The grain does not lodge or shatter to any extent when ripe. This is very popular in the large wheat sections of Nevada where the com-

bined harvester and thresher can be used. The kernels are generally rather soft, never having the flinty texture of the hard spring wheat, and are usually blended with the harder wheat for the manufacturing of good bread flour.

DURUM WHEAT. This type is often called Macaroni wheat. The spikes or heads are more heavily bearded than on Common wheat, and the plants somewhat resemble barley. The kernels are large, glossy and very hard, containing less starch than the Common wheat. It is used to some extent for bread flour, but its chief use is in the manufacturing of macaroni. It is necessary to sow more seed per acre with Durum than with Common wheat from the fact that the Durum wheats do not stool as well. In Nevada the Durum wheats yield less but withstand the alkali better than the Common varieties.



Method of testing varieties of small grains in rows, Nevada Experiment Station

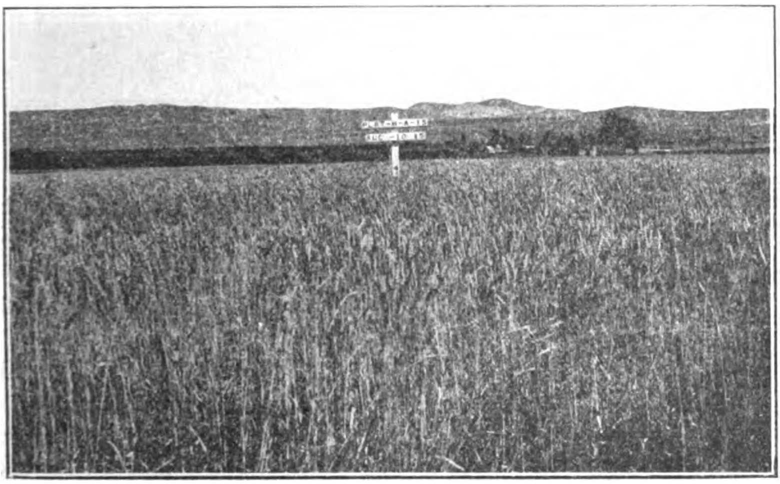
INVESTIGATIONS WITH WHEAT VARIETIES

The following table gives the average results of an investigation of wheat varieties for 1914, 1915 and 1916.

	WHEAT Variety	Origin of Seed	No. of hds pr. Stool	Ht. at harvest inches	Av. No. of grain pr. head	Yld. pr. acre straw Tons	Yield of Grain per Acre Pounds 1914	1915	1916	Aver.
1.	Galgalos Fife CI 2398	U. S. D. A.	12	45	20.0	3.9	....	4492	3471	3982
2.	New Zealand	Utah	10	55	35.7	4.0	....	2996	4097	3547
3.	White Club	Utah	12	41	37.4	3.3	3294	3096	3856	3482
4.	Defiance	Colorado	9	53	51.1	3.3	....	3023	3857	3435
5.	Blue Stem	Washington	11	52	33.1	4.1	3318	2855	3848	3340
6.	Colorado No. 50	Wyoming	14	42	33.3	2.9	2730	3625	3452	3269
7.	Glyndon No. 692	Montana	9	53	30.3	4.9	....	2274	3985	3105
8.	Marquis	Montana	14	44	33.5	3.2	2808	3505	2979	3097
9.	Chul	Utah	12	39	27.2	2.7	3222	3145	2879	3082
10.	Minnesota No. 163	Utah	8	55	31.6	3.9	....	2692	3365	3029
11.	Festes CI 1596	U. S. D. A.	10	46	28.6	3.8	....	2534	3304	2919
12.	Minnesota Fife	Minnesota	12	48	34.3	3.1	2100	3643	2978	2907
13.	White Australian	Idaho	7	43	45.1	2.3	816	3299	4052	2722
14.	Kubanka	Montana	9	53	39.6	2.7	....	2210	3194	2702
15.	Minnesota No. 169	Minnesota	8	56	37.9	2.7	....	2689	....	2689
16.	Stanley White	Montana	9	52	37.0	3.2	2724	2667	2554	2648
17.	Sonora	Utah	10	41	36.8	2.4	2878	2736	2166	2593
18.	Dicklow	Idaho	10	45	58.0	2.5	2238	2084	3197	2506
19.	Whitington	Utah	11	48	33.7	3.6	2136	2832	....	2484
20.	Medeah	Utah	10	53	31.9	3.5	1992	2563	....	2278
21.	Polish	Colorado	9	48	35.1	2.1	2836	1660	2092	2236
22.	Palouse Blue Stem	Idaho	10	47	30.4	3.0	....	2031	2328	2180
23.	Pelessier	Utah	10	42	21.8	3.8	2124	2207	....	2166
24.	John Brown	Wyoming	11	49	28.3	2.4	1584	3229	1494	2102
25.	Black Don	Utah	11	44	34.0	3.5	1350	2599	....	1975
26.	Ghirka CI No. 1517	U. S. D. A.	13	46	23.6	3.1	....	1896	....	1896
27.	Preston CI No. 3081	U. S. D. A.	11	45	24.5	3.2	....	1823	....	1823
28.	Egyptian Spring	Colorado	10	52	29.5	1.6	2046	1107	....	1577
29.	Wash. Hybrid No. 143	Washington	8	35	25.6	2.2	1662	1404	....	1533
30.	Glyndon Fife CI No. 2873	U. S. D. A.	13	48	27.3	3.0	....	1278	....	1278

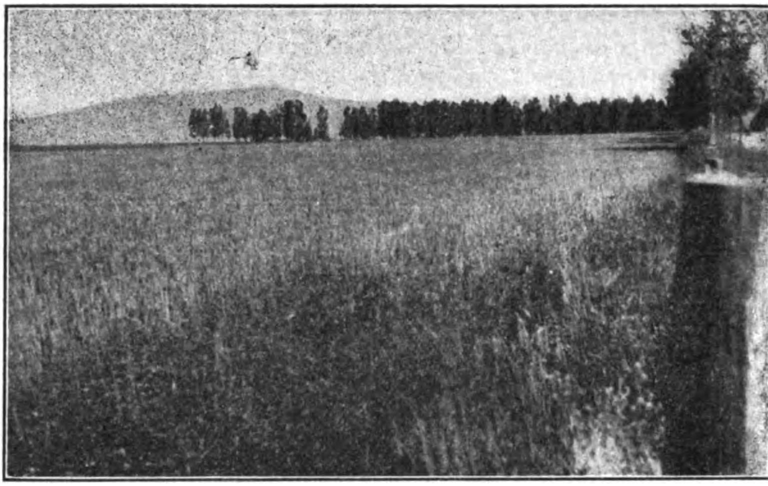
In this test a study was made of the number of heads per stool, height of plants at harvest, the average number of grains per head and the yield of straw per acre, but the variation in these factors was about the same with the high as with the low producing varieties.

Of the eight highest producing varieties for the three-year period White Club, Bluestem, Marquis, Minnesota Fife and White Australian have shown special adaptability when grown under irrigation in Nevada. Altho the White Club was the highest yielder, the value per acre was less than that of Marquis or Bluestem on account of its inferior quality for milling.



Marquis wheat producing over 40 bushels per acre with four seven-inch irrigations

On the well-drained valley lands of the State the Bluestem, Marquis and Defiance proved to be the best varieties that were grown on large areas in Nevada. The Bluestem wheat, the seed of which was secured from Washington, produced a white flour with a high gluten content of excellent quality. The Marquis seed was secured from Montana. It produced a red wheat with short, broad kernels. It is very similar to the Turkey Red hard winter wheat for milling, and in the local mills is replacing Turkey Red wheat which is shipped into the State in large quantities each year from Kansas and adjoining states to be mixed with the soft club wheat of Nevada for the manufacture of flour. The Marquis wheat sold to the mills in Nevada has commanded about the same price as the Turkey Red variety. If it maintains its hard kernel with high milling quality, this variety will be a valuable wheat for the farmers of the State.



Marquis wheat planted as a nurse crop with alfalfa at the University Farm

On the poorly-drained valley lands or on the humus soils the White Australian and White Club varieties have given the best results. Where the Bluestem and Marquis varieties were grown on the humus soils with a high water table in the lower Humboldt valley, not only the yield but also the quality of the wheat for milling was inferior to that of the White Australian and White Club. Very little difference was noted in the yield of the last two varieties under these conditions but the quality of the White Australian for milling was superior to that of White Club. It was noted, however, where the wheat was allowed to stand on the ground for several weeks after it had fully matured, the shattering of grain was greater with White Australian. The Bluestem variety is excellent in this respect in that it shatters very little for several weeks after it has ripened. When sold as a milling wheat, the White Australian was the more valuable of the two varieties.

In the test for the last two years the Galgalos Fife, New Zealand and Defiance were the highest producers. The two former varieties will be tested under field conditions, however, before they are recommended to the growers.

WHEAT SOILS

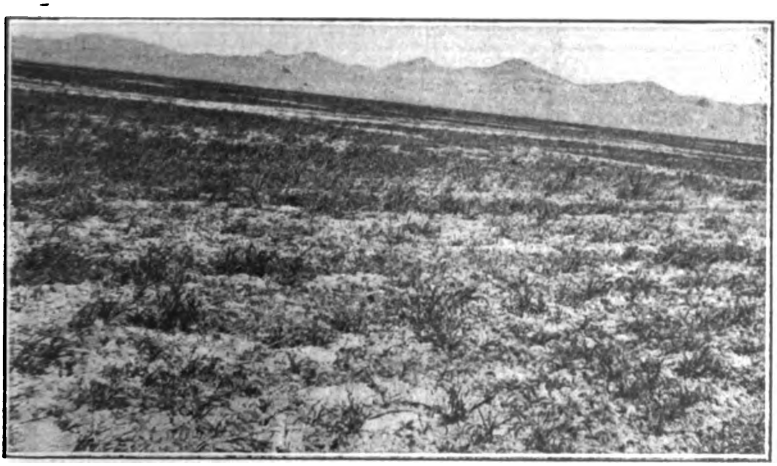
Soil. Although wheat is grown on a very wide range of soils, it produces the best crop in Nevada on the rather heavy fertile land. Some of the lighter soils produce good crops of wheat, but they are better suited to rye and barley. Wheat is well adapted to those soils that produce excellent crops of the cultivated grasses. The soil

may greatly affect the yield of wheat, but has little influence on the quality of grain. Although wheat cannot withstand any large amount of alkali in the soil, it has been found to produce excellent crops of grain on soils slightly impregnated with the salt.

ALKALI SOILS. In many of the irrigated districts of Nevada, large areas of land are impregnated with injurious quantities of alkali salts. The harmful effect of alkali in the production of wheat will depend upon the kind of alkali, whether black or white; the amount and distribution of alkali in the soil; and the system of drainage.

KIND OF ALKALI. Black alkali is a strong corrosive which destroys the plant tissue and affects the texture of heavy soils, making them more compact and in some cases impervious to water. This salt is composed chiefly of carbonate of soda, one-twentieth of one per cent of which will affect the growth of most crops. By continuous applications of gypsum to the soil, the black alkali may be converted into a less injurious salt which causes the soil to be less compact, thus permitting better drainage. This is practicable only where land is sufficiently valuable and gypsum is inexpensive.

White Alkali is more abundant in most localities than the black alkali and is less injurious. The white alkali salts are not corrosive, but when fully taken up by the plant they seriously affect its nutrition.



Wheat grown on land containing too much white alkali

HOW ALKALI AFFECTS THE WHEAT PLANT. An accumulation of salts at the surface during the period of seed germination, which might seriously injure the stand of many crops, may not prove in-

jurious to these same crops after their plant roots have attained considerable growth and have become well established in the soil below the concentrated solution of salts. For this reason seed should be planted so that the germination may occur immediately after an irrigation or a heavy rainfall, which will dilute the soil solution near the surface and allow the roots to go down into the soil before this solution becomes concentrated by evaporation.

Reclaiming Alkali Land. Drainage is one of the most important factors to be considered in the reclamation of alkali land. The most practical method of removing the alkali salts from land is by continuous flooding and drainage. This is often impossible for an individual farmer until a co-operative drainage system is established in his region. In reclaiming the heavy soils there is danger of impairing the texture by continuous flooding, which causes the soil to puddle. The growth of certain crops during this process may prevent to a large extent this puddling, provided the land is favored with a good drainage system or immediate outlet for this excess of water. If proper drainage is not present, this condition is usually associated with a high water table, which is especially unfavorable to deep-rooted crops like alfalfa and sugar beets, and by continuous irrigation the accumulation of alkali salts at the surface prevents the growth of shallow-rooted crops, like wheat and the grasses.

Amount of Alkali Wheat Can Withstand. Wheat will not do well where more than one per cent of the dry weight of the soil consists of alkali salts while with less than .6 per cent of salts a good crop can be produced. However, with the presence of over .5 per cent of salt in the top soil at seeding it is usually impossible to secure a uniform stand of grain. Certain experiments indicate that barley and rye are more resistant to alkali than wheat, but investigations in Nevada show little difference in the resistant powers of these grains to alkali. It has been noted, however, that with over .4 per cent of alkali in the soil, the heads of grain are usually not well filled and the grain is slightly shriveled.

Growth of the Wheat Plant. The growth of the wheat plant is influenced greatly by the presence of moisture in the soil. A large amount of water is required to bring the plant to maturity. In one season an acre of wheat will exhale an amount of water equal to a layer over the entire surface about one and one-eighth inches deep. If there is a shortage of water in the soil during the growth of the crop, the oldest leaves and those at the lower end of the stem are the

first to wither. Thus all available nourishment in the leaves and stem is taken to the upper part of the plant to bring the grain as far as possible to maturity. This condition is very noticeable in the dry farming districts, where the crop is stunted in growth due to lack of rainfall, when the seed is forming. Sometimes a crop of shriveled, poorly filled grain is matured on plants not over twelve inches high. If, on the other hand, too much water is furnished the crop, the tendency is for the leaves and stems to keep on growing and generally to decrease the yield of grain.

Experiments conducted with wheat under irrigation at the Nevada Station show that, when the crop reaches the boot stage, or when the heads are forming, the plant has accumulated over three-fourths of the nitrogen and mineral elements, but the starch is formed chiefly during the latter half of the period of growth. From the fact that the plant food constituents are being taken up through the plant to the kernels until the grain has matured, it is very important to harvest the crop, when used for hay about the time it is turning from the milk to the dough stage, so that the leaves and stems will be well supplied with nourishment and palatable to livestock. Wheat usually requires from ninety to one hundred and ten days after planting to mature a crop of grain in the important wheat districts of Nevada.

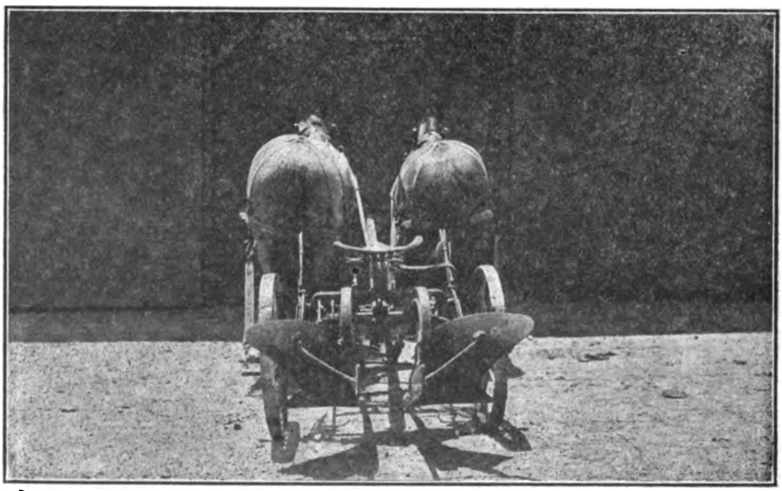
CULTURAL METHODS

Preparing Sagebrush Land For Wheat. In the preparation of sagebrush land the most difficult and expensive operation is that of removing the brush. When possible, this is most easily accomplished by burning. By this process it is possible to remove the brush from several acres a day when the wind is favorable. When done by hand, one-half an acre a day is the average work of one man. When the brush is not thick and does not grow very high, the ground may be cleared sufficiently for plowing by railing the brush. This a rapid method of removing the brush, but does not prove satisfactory where the brush is thick and high. The sagebrush grubbers or machines give very good satisfaction when sufficient power can be applied; however, in thick brush they do not work well unless operated by an engine.

The newly cleared ground should be plowed to a depth of eight or ten inches. This will bring all sagebrush roots to the surface, and will also make a reservoir deep enough to catch all of the rainfall. Deep plowing is one of the most essential factors in preparing the seed bed, generally the one neglected by the farmer. Without a

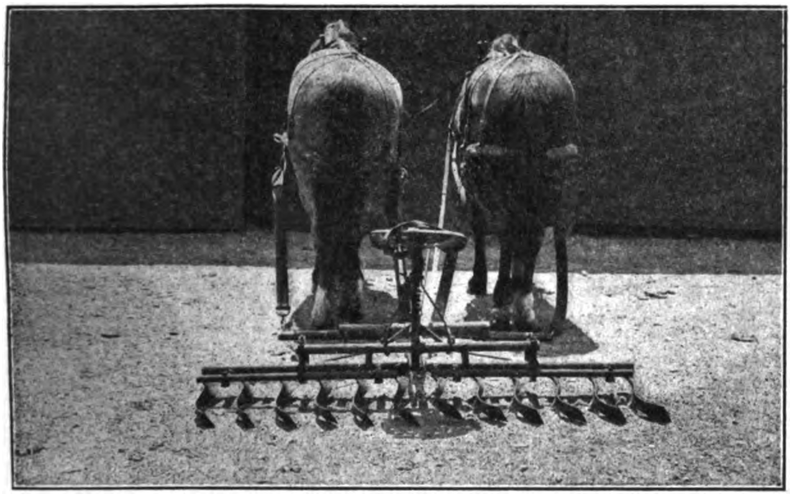
deep seed bed, it is difficult to store all of the water from the rain and snow. In this State it is most desirable to plow in the late fall, since the greater portion of the rainfall and snow comes during the winter and early spring months, and in a rough condition the plowed ground is prepared to catch all of the precipitation.

After the newly cleared ground is plowed the sagebrush roots should be removed immediately; that is, the same day, with spring plowing, since it is impossible to properly pack the soil that contains these roots. For this purpose the alfalfa cultivator is a very useful implement, especially with large roots. Where the roots are small and easily separated from the soil, the common smoothing harrow or hay rake may be used. Fall-plowed ground that is cleared of roots is best left in the rough condition until spring, when the disk harrow should be used as soon as the ground can be worked, and this followed immediaetly by the smoothing harrow.



Reversible or Two-way Plow, an excellent implement in preparing land for grain, since it leaves no dead furrow

PLOWING. Both fall and spring plowing are practiced in preparing the ground for spring wheat, but fall plowing, since the soil is exposed to the freezing and thawing weather which aids in breaking up the soil, is most destructive to weeds and insects and is the most economical in farm practice. For winter wheat the ground should be plowed as soon after harvest as is practicable. This allows the soil to become compact before seeding and destroys the weeds before they ripen their seed.



Knife or "Acme" Harrow

Where dry farming is practiced, as soon as the crop is removed the ground should be disked. It is usually not possible to plow for several weeks later and this disking breaks up the surface crust which has formed during the summer and prevents further rapid loss of water by evaporation. The ground may also be plowed more easily and perfectly when the plow follows the disking. If the ground is too dry, it should not be plowed at this time, as the ground will be left rough and lumpy. Care should also be taken not to plow the ground when too wet, since it is likely to form a hard, dry crust on the surface. The depth of plowing should not be less than four inches, nor more than eight inches. It is seldom necessary to plow more than six inches as the extra deep plowing seems to affect the yield of straw more than the yield of grain.

Where wheat is grown in the dry farming areas, the seed bed should be deep and well cultivated, so that it will have a sufficient water-holding capacity to catch all of the moisture from the rainfall. Where the conditions are such as to permit deep plowing, one plowing is often sufficient; otherwise two plowings will be necessary to furnish a sufficiently deep seed bed of loose earth.

The object of cultivation is not only to furnish a reservoir for moisture, but also to prevent the loss of this moisture from the soil by evaporation. Since the greater part of the precipitation in arid regions comes during the winter and early spring months the ground should be put in a more or less rough condition in the fall to catch the snow and rain, and also to prevent any great loss of soil from blowing.

Ground that is in a smooth condition in the fall should be disked. Ground that has been fall-plowed is in good shape to absorb moisture. Land that lies rough does not freeze as land which lies smooth, and it also thaws out quicker.

Preparing the Seed Bed. Wheat requires a finely pulverized well-firmed seed bed. If the land has not been plowed several weeks before the time of sowing, the roller or packer should be used. This fills the spaces, breaks the large clods and puts the soil in a good condition to draw the moisture from below, which insures a rapid and uniform germination of the seed. The roller should be followed immediately by the smoothing harrow which will prevent a crust from forming on the surface and also rapid loss of water by evaporation. If a roller is not accessible a common leveler or planker will prove valuable in filling the low places and breaking the clods. Fall plowing usually does not require any rolling or packing in the spring. Disking and harrowing generally provide sufficient cultivation for a good seed bed.

Seeding. The depth of sowing depends largely upon the kind of soil and its physical condition. When the soil is moist near the surface, it is not necessary to place the seed below one to one and one-half inches deep, but if the soil is loose and dry, deeper seeding is required. Usually the wheat is sown from one to three inches deep.

In dry farming areas of Nevada when planting winter or spring grains, it is a common practice to drill the seed deep enough to reach sufficient moisture to insure germination. From the fact that winter precipitation is generally assured, it has been found desirable to plant fall grains not over four inches deep. If sufficient moisture is not present at this depth for germination, the seed is generally sprouted by later precipitation and the roots are well established in the soil before the spring growth begins. When seed is planted less than three or four inches deep, the young plants soon make their appearance above the surface and the leaves provide for rapid development of tops and roots, thus assuring a uniform stand of the crops.

In the important winter wheat sections of Nevada most of the grain is planted during the month of September. Spring wheat is generally sown as soon as the seed bed can be properly prepared in the spring This gives the plants opportunity to use all available moisture in the soil and to better resist attacks from disease and in-

sect enemies. In some of the irrigated districts of Nevada, the spring wheat is sown in February and March to make use of the early spring water.

The amount of seed to sow per acre varies greatly with the condition of the seed bed and the type of farming. A well prepared seed bed can stand a heavier seeding than one left in a rough, cloddy condition. In the irrigated districts usually seventy-five to ninety pounds per acre give the best returns.

In dry farming less seed is required per acre. The rate of seeding crops for dry farming varies somewhat with the locality, but the general practice is to sow about one-half as much seed as is used under irrigation.

The two general methods of sowing wheat are broadcasting and drilling. Broadcasting may be done either by hand or machine, but this method is not as satisfactory as drilling, which distributes the wheat more uniformly and plants it at a more uniform depth. By the latter method the wheat is also placed down in moist soil which insures germination and it not so easily killed by freezing and heaving.

TREATMENT OF WHEAT FOR SMUT

Formalin may be secured from any reliable druggist. Make up the solution by mixing one pint of formalin (40 per cent solution of formaldehyde) to 40 gallons of water. Put the grain to be treated in sacks, about a bushel to a sack, then dip each sack into the barrel containing the solution and allow it to remain from 7 to 10 minutes. Move the sack up and down in the solution several times so as to make sure that all the grains are thoroughly wet. Then lift the sacks and allow the solution to drain out, after which pile the sacks of treated grain together and cover with bagging or canvas, or pour the treated grain in a pile out upon a clean floor and cover with bags or canvas from 12 to 24 hours. Finally spread the grain thinly over a clean floor to dry. The object of covering the grain for such a long period after treatment is to prevent the formaline from evaporating, so that it will keep in contact with the grains long enough to kill the smut spores.

After this treatment the grain should be dried as rapidly as possible to prevent sprouting. When thoroughly dry, the grain should be put in clean bins or sacks, so as not to be again exposed to the disease. Sacks and bins may be disinfected by washing with a formalin solution, using one pint of formalin to 10 gallons of water.

Copper Sulphate or Bluestone Treatment. Use one pound of crystalized commercial copper sulphate or bluestone to 25 gallons of water, and immerse the grain 12 hours, stirring occasionally; then immerse for a few minutes in lime water, using one pound of good slacked lime to 10 gallons of water to avoid injury to the germination of the seed. The copper sulphate treatment may also be applied as with the formalin by immersing the seed for 10 minutes, piling in a clean place, covering with bags or canvas for 12 to 24 hours, as explained above.

Test Seed For Germination Before Planting. Wheat one year old often gives a better germination test than fresh seed, but after the first year the grain diminishes in vitality from year to year. Wheat has been known to be viable after ten years, but it is not advisable to sow wheat after two or three years without first testing it for germination which often varies from fifteen to seventy-five per cent. A simple method of testing seed for germination is to plant the kernels between folds of cloth or blotting paper, one end of which is placed in water so that the moisture is supplied through capillarity. The germination should be kept at the ordinary room temperature and never allowed to fall below 50 degrees F.

In giving wheat the copper sulphate treatment for smut the viability of the seed is often impaired, especially, if the seed is not washed in lime water after it has been taken from the copper sulphate solution.

Cultivation. In the irrigated districts wheat is seldom cultivated after it is sown, but where dry farming is practiced it becomes necessary to harrow the crop at various intervals until it is about six inches high to kill all weeds and preserve a mulch on the surface to prevent evaporation.

The cultivation of spring wheat after it is up has not been a common practice, since in many cases it has been found detrimental. Winter wheat is often rolled in the spring, where there is much heaving of the soil, so that the soil may be packed about the roots. Sometimes early spring harrowing is resorted to in order to break up the hard crust which has formed during the winter and to keep a loose, dry mulch on the surface to conserve the moisture. Late harrowing and late rolling are often injurious.

In the dry farming districts, the usual practice is to give the field a cultivation after planting with the spike-tooth or smoothing harrow, running at right angles to the direction of the drill, and set-

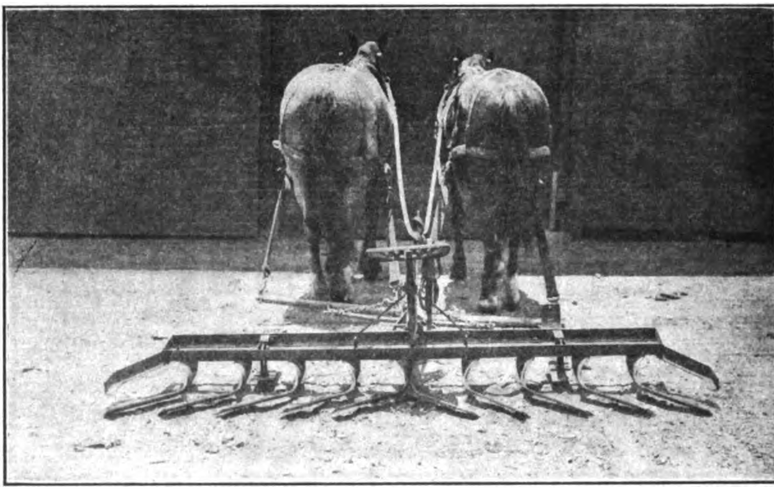
ting the harrow teeth at an angle of about forty-five degrees so that the seed will not be disturbed. If a corrugated sub-surface packer can be obtained, a more uniform germination of the seed will be assured. if the field is packed with this implement. No more cultivation should be given until the grain is four or five inches high. The grain crops seldom require more than three or four cultivations, each of which generally occurs after a rainfall, to break up any crust which may form on the surface, and thus conserve the moisture in the soil. When the grain has reached the height of twenty inches; the ground is well shaded and no further cultivation should be given.

SUMMER FALLOWING IN THE DRY FARMING DISTRICTS. In the dry farming regions, where the annual precipitation ranges from ten to fourteen inches, summer fallowing is necessary for the production of profitable crops. In most sections it may be every other year, or in more favorable localities every third year. That is, it will require the storage of moisture of two years for one crop, or in the second instance the storing of the moisture of three years for two years of cropping. In all dry farming sections of Nevada, it will be found more certain and profitable to summer-fallow every alternate year. By dividing the field into two or more sections it is possible to secure a crop every year and at the same time obtain but one crop every alternate year from a given field. There are several reasons for cropping a given soil only every alternate year, which are summed up in Bulletin 63 of the Montana Experiment Station, as follows:--

"By proper summer fallow moisture is accumulated to a greater depth than is possible when crops are grown every year. This insures safer growing conditions for the succeeding crop. When a field is cropped every year, the moisture is so fully utilized by the growing plants that the essential bacterial activities, which bring the plant food of the soil in an available state, are greatly hindered; thus the food necessary for the production of large crops is not available. Also, if the moisture is not present in a sufficient amount to produce these activities, the vegetable matter in the soil will not decompose, and the required humus content cannot be maintained."

There is some question as to the best time to plow for summer fallow. When ground is plowed in the fall, the weathering of the soil is more complete due to the action of the winter rain and snow and freezing The soil seldom requires packing and it has been claimed by Utah farmers that more moisture is conserved by fall plowing.

When spring plowing is practiced, the ground should be disked in the fall as soon as the crop is removed. This puts the ground in better condition to catch the rain and snow This practice also makes the fall plowing easier and more satisfactory.



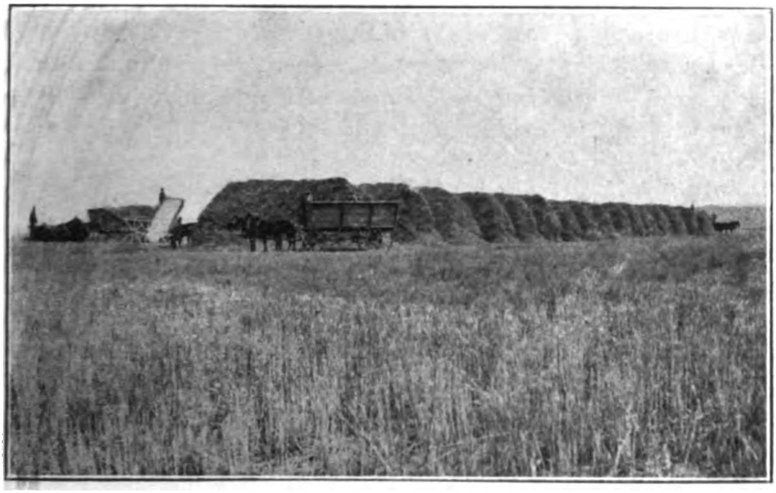
Knife weeder, a valuable implement in keeping summer fallowed land free from weeds

It is important that the field which is summer-fallowed should receive frequent cultivation. This is not only essential to conserve the moisture, but for the eradication of all weed growth. If a hard crust is formed on the surface, or if weeds are allowed to grow, considerable moisture is lost. Weeds not only exhaust the soil of moisture, but they may act as a poison on the succeeding crop. Weeds will sprout quickly after a rain, and at this time there is also danger of a crust forming on the surface of the soil. By harrowing the field with a spike-tooth harrow as soon as the ground is dry enough to be worked, the crust may be broken and the small weeds killed. If the growth of weeds has become rank, the disk harrow or knife weeder will probably have to be used for their eradication.

IRRIGATION OF WHEAT

METHODS OF IRRIGATION

FLOODING FROM FIELD DITCHES. This is the cheapest method to install and the most wasteful of water, also a great deal of labor is required in distributing the water over the field. It is sometimes called the contour method, since the field ditches carry the water along the ridges and distribute it down the slopes over the field.



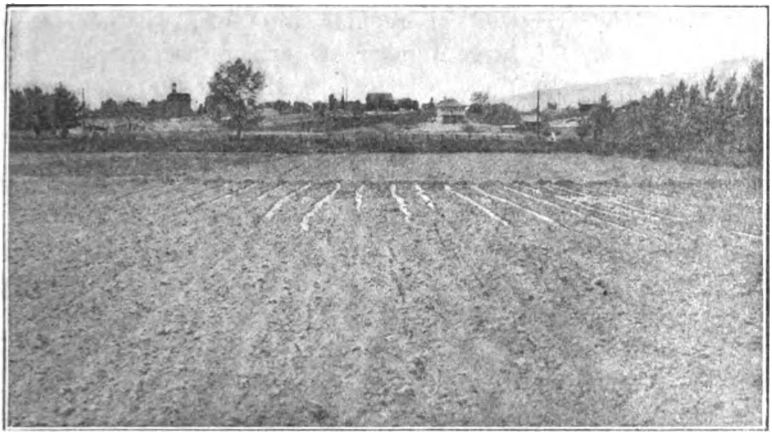
Turkey Red winter wheat during harvest at Metropolis, Nevada

BORDER METHOD. This is possible on comparatively level land. In preparing the field for this system the greatest care must be exercised in leveling the land accurately for the borders. A leveler commonly used in Nevada for this purpose is mounted on four wheels with a heavy iron blade which works something on the order of a road grader. Eight horses are generally required to pull the leveler and two men for its operation, one driving and the other to operate the machine. On new land it is necessary to plow the ground before leveling, but on stubble land under cultivation the work can be done before the plowing is commenced. When the field is properly leveled with this implement, the borders are marked off on the head line from sixty to ninety feet wide. A huge V marker and ditcher is then used to make the levees which run at regular intervals, separating the borders. This is a heavy implement mounted on four wheels and controlled by a system of levers, and requires about twice as much power for its operation, as the leveler. After these borders are seeded, a head ditch is then made with the same ditcher to carry the water to the borders. If one man is applying the water, he turns in as large a head as can properly be handled. Considerable experience is needed in this system of applying the water, because as soon as the soil at the upper ends of the borders is sufficiently wet, the water must be taken down the ditches between the borders to irrigate the lower portions of the land. These borders vary from 1000 to 5000 feet in length, depending upon the slope of the land. With a properly installed system the water can be brought down one side of the field for a considerable distance in a

diagonal direction, instead of bringing the water down the ditch and turning it into the borders at frequent intervals. In this way a large tract can be irrigated by one man in a day. In sections of Nevada where this system is practiced, wonderful crops of wheat are produced, but in such regions the soil is of a loose nature, contains large amounts of humus and does not bake after wetting. In this system one experienced irrigator can handle about six second feet of water.

FLOODING IN CHECKS. In this system of irrigation the levees are run across the field in both directions, dividing it into a series of basins. This system is largely practiced on new lands that require a great deal of leveling. By this method the level tracts can be checked ready for the water without a great deal of expense. This system is also desirable on lands that will not soak up well, when the water is run in the furrows. On the Truckee-Carson Irrigation Project, where this system is commonly used in the production of hay and grain, the levees dividing the checks or basins are wide and low and are generally covered with a crop. They are constructed to prevent any waste of land and to make possible the harvesting of the crop with the mower or binder. In such a system some checks are higher than others. Water is turned into the higher checks, and, when sufficiently wet, it is taken off and run into the lower checks, and so on until all the ground is irrigated. Although considerable water is lost by evaporation, very little goes into the drainage ditches. If land has a gentle slope, the installation of this system is very expensive, as compared with the border method and flooding from field ditches. A large head of water can be used with this system and one man can handle from seven to eight second feet.

FURROW IRRIGATION. Where the conditions are suitable and the land is sufficiently friable and mellow, the furrow method of irrigation is best adapted to the highest returns in the production of grain in Nevada. In this system the water is run through the field in small furrows and diffuses laterally through the soil, but should not run over the surface. This system is adapted to small streams, considerable slopes and to heavy soils. The water may be run in a few or many furrows, it may be run across the slope at any angle for the desired flow of water and it gives the heavy soils time to soak up. The feed ditches are nearly level and are generally run across the slope of the field. In Nevada a great deal of trouble has been encountered in the washing away of the banks, when the water is taken from the distributing ditch to the furrows. This condition has been met by the use of galvanized iron pipes from one and one-half to



Furrow method of irrigating small grains

two inches in diameter and two feet long. These iron pipes are placed in the bank of the distributing ditch and each pipe furnishes water for from two to six furrows, depending upon the head of water in the feed ditch. By such a system a large field can be irrigated by one man, since his chief duty is to see that the proper head of water is maintained in the distributing ditches. Also, the water is more evenly distributed in the furrows, so that it reaches the lower part of the field in the different furrows at about the same time.

The length of furrows varies with the slope of the land and the nature of the soil from 200 to 800 feet, the greater lengths being possible in the heavy soils with the gentle slopes. Feed ditches are run across the field at these intervals of from 200 to 800 feet and in turn furnish water for the irrigation of the check below. By making the furrows after the land is planted, no land is wasted. Although the initial expense is great in installing this system, the water is very easily handled and the expense of irrigating is small. With this system a much smaller head of water is used than with the other methods.

Amount and Time of Irrigation. The time to irrigate grain must be determined largely by the condition of the crop and the moisture content of the soil. Some irrigators determine this period by the color of the wheat which turns dark green, when in need of water. Others examine the first six inches of soil and learn by this method when the crop needs water. Still others contend that the

crops should be irrigated at regular intervals, whether the crop needs it or not. A large number of farmers use the last method for determining the time to irrigate and thus the crop generally receives a great deal more water than is required and the yield and quality of the grain is often greatly affected by this practice. Unless the soil is very heavy in texture or varies greatly, the ground should be irrigated before planting. If heavy clay land is irrigated before seeding, sometimes several weeks are required for the soil to become dry enough to be worked and the weeds present are apt to be troublesome. When a field includes both light and heavy soils, a uniform stand of grain is quite impossible and, if irrigated when the young plants are starting their growth above the ground, they are greatly checked in growth by the application of water at that time. Thus, such soils are generally irrigated after the grain is planted to germinate the seed. When irrgiation is necessary immediately after planting, there is considerable danger of baking and crusting the soil, so that the ground will have to be irrigated again to soften the crust or cultivated with a corrugated roller or spike-tooth harrow with the teeth sloping well back to let the plants slip through.

The irrigation after germination should be withheld as long as possible to give the plants a chance to establish a good, vigorous root system in the soil to furnish the proper nourishment for the development of grain later on. However, the water should not be withheld until the lower leaves turn yellow. As a rule, the first irrigation after the grain has started is given between the time the five leaves are formed and the boot stage. If irrigated at the five-leaf stage, the second application is made at the boot stage, the third at the bloom, the fourth at the milk and the fifth at the dough stage. If the first irrigation is not required until the plants reach the boot stage or when the heads are forming, only four irrigations should be given. If only three irrigations are possible, the best results are recorded when applications are made at the boot, bloom and milk stages. However, this will vary with the nature of the soil, amount and distribution of annual precipitation, and the preparation of the seed bed. The proper time must be largely determined by the condition of the crop and the moisture content of the soil.

In many wheat sections of Nevada, heavy winds are common early every afternoon. In such localities the rank, growing grain which is approaching maturity should be irrigated at night or in the forenoon during the calm spell. This gives the culms which soften near the surface of the ground time to become firm before they are

blown to the ground by the heavy wind. The last irrigation should never occur too late, especially in windy climates.

IRRIGATION INVESTIGATIONS WITH WHEAT

The following table includes the results of investigations on the irrigation of wheat for a period of three years:

IRRIGATION OF WHEAT

Table showing increase in yields of seven-inch applications over three-inch applications in percentage for 1914, 1915 *and* 1916

	YIELD PER ACRE IN BUSHELS								Average
One irrigation omited at	3 in. application 1914	1915	1916	Av.	7 in. application 1914	1915	1916	Av.	Per cent Increase
Five leaf	21.2	26.2	31.3	26.2	32.6	36.8	35.3	34.9	33.2
Boot	17.1	15.3	29.6	20.7	31.8	28.9	20.1	27.2	31.4
Bloom	19.4	14.0	24.9	19.4	24.2	26.3	31.7	27.4	41.3
Milk	27.1	28.6	29.2	28.3	26.2	28.4	37.0	30.5	7.8
Dough	29.4	21.8	32.8	28.0	32.3	25.1	34.2	30.5	8.9
Two irrigations omitted at									
Five leaf and boot	21.8	14.8	20.7	19.1	22.5	18.6	17.1	19.4	1.6
Five leaf and bloom	15.9	20.7	30.9	22.5	22.9	16.9	25.9	21.9	2.7
Five leaf and milk	22.5	25.8	33.4	27.2	19.2	31.8	43.3	30.1	10.7
Five leaf and dough	10.1	32.4	35.7	26.1	29.8	27.2	34.6	30.5	16.9
Boot and bloom	7.8	12.8	21.0	13.9	12.6	12.5	25.6	16.9	21.6
Boot and milk	14.8	21.3	29.4	21.8	16.9	21.2	36.8	25.0	14.7
Bloom and milk	15.6	20.3	29.4	21.8	18.3	19.3	34.4	24.0	10.1
Bloom and dough	16.2	19.1	37.6	24.3	23.9	24.8	39.3	29.3	20.6
Milk and dough	20.0	28.1	37.8	28.6	25.0	30.5	34.4	30.0	4.9
No irrigations omitted	26.0	26.9	32.1	28.3	24.2	26.1	43.1	31.1	9.9

ONE IRRIGATION OMITTED. The results are strongly in favor of the 7-inch applications. The average yield for the 7-inch applications was 24.5 per cent greater than that for the 3-inch applications. The highest yield of 34.9 bu. per acre was obtained when the irrigation at the five-leaf stage was omitted. When irrigations were omitted at the milk and dough stages respectively, the same yield of 30.5 bu. per acre was secured.

The lowest yields with both 3 and 7-inch applications were found when irrigations were omitted at the boot and bloom stages respectively.

When a 7-inch application was given at each stage of growth or a total irrigation of 35 inches, the yield was 31.1 bu. per acre or 12.2 per cent less than where only 28 inches of water were applied and the irrigation omitted at the five-leaf stage. This was due chiefly to the greater development of root system where the first irrigation was omitted, and at the same time the plants did not suffer from lack of sufficient moisture before the irrigation at the boot stage.

Two Irrigations Omitted. Here also the results are in favor of the 7-inch applications although not to such a great extent as where only one irrigation was omitted. The average yield for the 7-inch applications was 11.5 per cent greater than that for the 3-inch applications.

The four highest yields were obtained when irrigations were omitted at the five-leaf and dough, five-leaf and milk, milk and dough, and bloom and dough, in the order named, the greatest production being 30.5 bu. per acre, and the lowest 29.3 bu. per acre, or a difference of about four per cent.

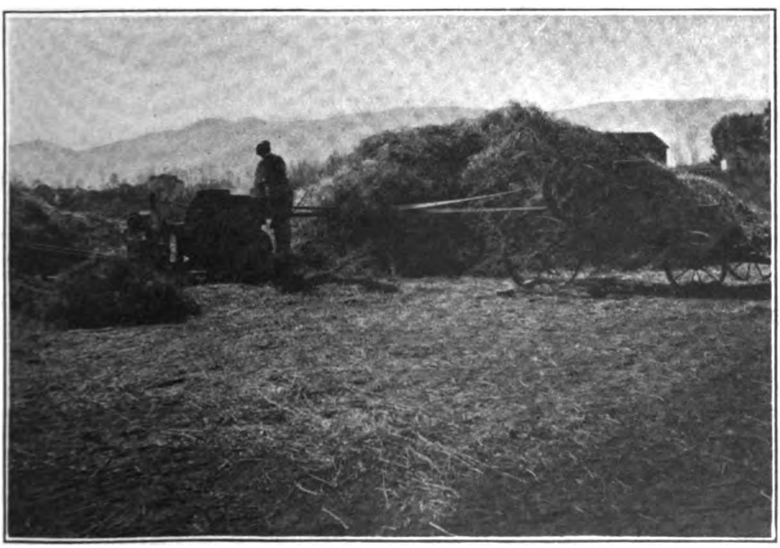
The three lowest yields with the 7-inch applications averaging 19.4 bu. per acre were obtained when the irrigations were omitted at the five-leaf and bloom, five-leaf and boot, and the boot and bloom stages, the last yield being 16.9 bu. per acre.

The low yields with both 3-inch and 7-inch applications when irrigations at the boot and bloom stages were omitted, indicate that the most critical stage in the irrigation of wheat is between the boot and milk stages. When irrigations were omitted at the five-leaf and milk, and five-leaf and dough stages practically no difference was noted in the yield, the average being 30.3 bu. per acre.

Harvesting and Threshing. It is a common practice in Nevada, where the binder is used to begin harvesting a little before the wheat is ripe, as this decreases the loss due to over-ripeness, and with proper care does not diminish the yield. If the harvesting is delayed until the kernels become hard, there is danger of considerable loss from shattering. Also in the last stage of ripening practically all of the starch for the grain comes from the culms and leaves, thus the crop may complete the ripening after it is placed in the shock, providing it is not cut too early. If the grain is checked in growth by lack of moisture or some other factor, the amount of starch in the ripened grain will be comparatively low. One reason for the high protein content of the hard winter wheats of our dry farming districts may be attributed to the low development of the starchy endosperm.

A combine Harvester and Thresher at work in the Lovelock valley

Where the combined harvester and thresher is used, the grain must be thoroughly ripened, as it is harvested and threshed in one operation. When this machine is used in harvesting grain that is not fully ripe, the grain will go through the sweat in the sack, and may result in serious loss due to heating and molding. Frequently the presence of green weeds in the field at harvest will produce the same injury to the grain. This last condition can be avoided by thoroughly cleaning the grain within a few days after harvest to get rid of all green leaves, stems and seeds.



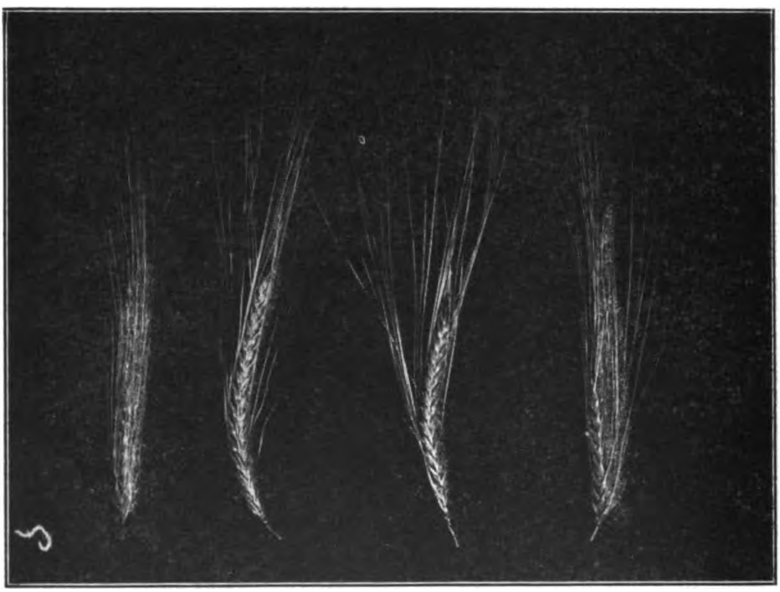
Outfit used at the Nevada Experiment Station for threshing small plats of seed crops, without danger of mixing the varieties

Practically all wheat raised in Nevada is placed in sacks and loaded on the cars for shipment or stored at the local warehouse or elevator. Jute bags are getting more expensive each year, and in

many instances some plan should be adopted to eliminate the use of sacks, and thus cut down the expense of marketing the wheat. This may be accomplished by establishing elevators in the important wheat sections, and transferring the wheat from these elevators to the mills without the use of bags. Such a plan has been agreed upon by a local mill and the growers in one of our important wheat districts.

BARLEY

Nevada produced about 15,000 acres of barley in 1916, one-half of which was grown in the counties of Churchill, Lyon and Douglas, and another one-fourth in Humboldt and Elko counties. Barley is the principal cereal grown in Southern Nevada. Lincoln and Clark counties producing about nine per cent of the total production for the State. Practically all of the barley grown in Nevada is used



Barley from left to right
1. California Feed (Colo.) 6 R. 3. Chevalier (Nev.) 2 R.
2. Moravian (Ida.) 2 R. 4. Brewing (Wash.) 6 R.

as a feed for livestock, and is generally fed in connection with alfalfa. A small acreage of winter barley is grown each year in the dry farming districts of the State, but under irrigation only the spring barleys are grown. The six-rowed barley is the type most commonly grown, but the results of experiments for the past three years showed that the two-rowed varieties produced larger yields of grain with plumper and heavier kernels. The acreage of two-rowed barley in Nevada is rapidly increasing.

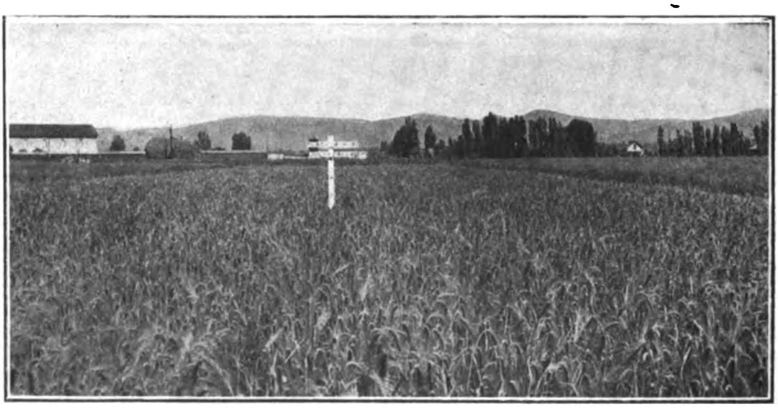
INVESTIGATIONS WITH BARLEY VARIETIES. The following table includes a study of barley varieties for the last three years:

	BARLEY Variety	Origin of Seed	No. of hds pr. Stool	Ht. at harvest inches	Av. No. of grain pr. head	Yld. pr. acre straw Tons	Yield of Grain per Acre Pounds 1914	1915	1916	Aver.
1.	Swedish Gold	Sweden	10	31	24.9	3.3	....	....	4763	4763
2.	New Zealand	Montana	8	36	28.8	3.3	....	2740	4917	3829
3.	Blue Ribbon 2 rowed	Montana	13	36	26.3	2.7	3040	3443	4025	3503
4.	Brewing	Washington	7	36	47.0	1.6	....	3125	3823	3474
5.	C. I. No. 679 France	Wyoming	11	36	24.7	2.2	1469	3260	4924	3218
6.	White Smyra	Idaho	13	27	21.9	2.2	2395	2522	4667	3195
7.	Princess	Idaho	8	34	27.0	2.9	....	2012	4352	3182
8.	Calif. Feed	Colorado	10	32	48.9	1.8	2367	2814	3975	3052
9.	Trebi C. I. No. 936	Idaho	7	35	51.9	1.9	....	2197	3886	3042
10.	Chevalier	Nevada	11	35	27.1	2.7	2720	2660	3625	3002
11.	Hanna 2 rowed	Colorado	8	38	26.7	2.6	1618	3340	3991	2983
12.	Moravian 2 rowed	Idaho	10	35	24.4	2.6	3086	2502	3294	2961
13.	No. 682 Hells Hanna	Wyoming	12	36	22.4	2.5	3023	1550	4166	2913
14.	No. 19785	Oregon	11	36	29.7	2.3	1465	2734	4314	2838
15.	C. I. No. 652 Poda U. S.	Wyoming	7	36	41.4	1.9	1125	3141	4063	2776
16.	White Moravian	Fallon, Nev.	11	37	25.2	2.8	3315	1561	3432	2769
17.	Wash. Hulless	Washington	11	34	48.0	2.3	2327	1974	3605	2635
18.	Mariont	Fallon, Nev.	9	27	41.1	1.8	1872	2291	3723	2629
19.	White Winter or Spring	Wyoming	9	34	63.2	2.1	1872	2135	3797	2601
20.	Swanneck	Fallon, Nev.	10	37	27.3	2.1	1872	2354	3478	2568
21.	Hanchen	N. Dakota	10	36	27.2	1.7	653	3198	3794	2548
22.	No. 22303—2 rowed	Wwoming	9	35	28.8	2.6	1057	2633	3871	2520
23.	Beldi	Oregon	9	32	46.9	1.8	2766	1194	3487	2482
24.	Eureka	Washington	8	35	47.7	2.0	....	2139	2811	2475
25	Guy Mayle	Montana	10	30	52.5	1.8	1061	2740	2707	2169
26.	Manchuria	Nevada	9	37	51.3	2.2	1325	1867	2804	1999
27.	Success	Utah	12	31	44.8	1.7	1397	2546	....	1972
28.	Colorado Blue	Colorado	10	29	35.2	3.7	2066	1823	....	1945
29.	Svanhals	Fallon, Nev.	11	37	25.8	3.9	1775	1925	....	1850
30.	U. S. No. 12709	Colorado	10	32	47.3	3.6	1570	2090	....	1830
31.	White Hulless	Colorado	9	34	46.8	3.6	2184	1409	....	1797
32.	C. I. No. 530 S. Dakota	Wyoming	10	34	24.3	3.7	1675	2781	....	1771
33.	Scotch 4 rowed	Colorado	8	39	41.6	3.6	1215	2111	....	1662
34.	Californian	Utah	11	32	44.1	3.8	1872	1435	....	1654
35.	Wis. Ped. No. 9	Wisconsin	9	40	49.7	3.7	1118	2086	....	1602
36.	Silver King	Idaho	11	37	50.3	3.8	1060	1964	....	1512
37.	Oderbrucker	Nevada	11	40	60.0	4.2	1589	1300	....	1445
38.	Ont. Ag. Col. No. 21	Oregon	9	35	58.5	3.4	1190	1448	....	1319
39.	Calif. Prolific	Utah	7	33	39.9	1.1	....	1119	....	1119
40.	Wisconsin No. 6	Wisconsin	9	35	56.0	3.3	783	829	....	806

In this test a study was made of the number of heads per stool, height of plants at harvest, the average number of grains per head and the yield of straw per acre, but the variation in these factors was about the same with the high as with the low producing varieties.

The New Zealand variety produced the heaviest yield for the two-year period of 80 bu. per acre, while Montana Blue Ribbon had an average production for the three-year period of 73 bu. per acre. The results of this experiment favored the two-rowed varieties of barley.

SOIL. In most parts of Nevada, barley is grown with equal success in the sandy loam and clay loam soils, provided the heavy soils are well drained. When grown on soils too heavy, the young barley plants are usually seriously checked in growth by an excess of soil moisture. Thus heavy soils with relatively high water tables should be cropped to wheat which is more of a shallow feeder like the grasses, and is not so seriously affected by a high water table. Some of the biggest crops of barley produced in Nevada, have been grown



A field of Manchuria Barley yielding 75 bushels per acre

on well drained clay loam soils. Barley, however, is much better adapted than wheat to the sandy loam soils. Barley and wheat grown on soils slightly alkali have shown very little difference in their power to withstand an excess of salts. In certain instances, the barley grain was slightly less shriveled than the wheat, indicating that the greater power of resistance to alkali was in favor of the barley.

CULTURAL METHODS. For the highest yields with barley, the seed bed should receive the best preparation, as outlined under wheat culture. Usually the best yields are obtained by sowing from 90 to

110 pounds of seed per acre. With barley, more seed is required per acre than with wheat from the fact that it does not stool as freely as wheat.

In treating barley for smut use one pint of formalin to 20 gallons of water. Immerse the sacks of barley in the solution for 10 minutes, and follow treatment as with wheat.

Use the same method of irrigation for barley as that outlined for wheat.

In this State, barley is harvested with a little greater difficulty than the wheat. This is due to beards on the barley, which are sometimes troublesome in shocking. Beardless barley has been grown to some extent in Nevada with an idea of overcoming this difficulty, but in most instances it has not given as good results as the bearded varieties. In threshing barley, there is great danger of breaking the grain by running the cylinder at too great a speed. A little care in this respect will greatly increase the value of the barley for seed.

OATS

In 1916, about 15,000 acres of oats were produced in Nevada, of which over 40 per cent was grown in Elko County, and about 85 per cent in Elko, White Pine, Churchill, Lyon and Douglas counties.

Oats is not as well adapted to the irrigated districts of Nevada as wheat or barley.

The lack of humidity together with the intense heat of the sun during the ripening period often causes the panicles to blast and turn white before the grain is fully developed, and while the culms and leaves are still green. When affected in this way, a large portion of the oats shatters to the ground before and during harvest.

INVESTIGATIONS WITH OAT VARIETIES

The following table includes the results of a three-year test of oat varieties:

	OATS Variety	Origin of Seed	No. of hds pr. Stool	Ht. at harvest inches	Av. No. of grain pr. head	Yld. pr. acre straw Tons	Yield of Grain per Acre Pounds 1914	1915	1916	Aver.
1.	Early Mountain No. 2 C. I. 656	U. S. D. A.	9	47	46.7	3.0	....	2185	3042	2614
2.	Early Mountain	Idaho	7	49	34.0	3.0	....	2041	2187	2114
3.	Black American C. I. 549	U. S. D. A.	10	46	33.8	2.1	....	1844	1937	1891
4.	Banner C. I. 751	U. S. D. A.	9	48	28.9	3.0	....	1922	1853	1888
5.	White Danish	Montana	6	50	37.2	3.8	....	2011	1308	1660
6.	Siberian C. I. 741	U. S. D. A.	8	47	31.1	2.8	....	2054	1222	1638
7.	Ont. Agr. Col. No. 72	Montana	6	52	25.7	3.3	....	1847	1055	1451
8.	Big Four	Idaho	12	47	47.8	3.2	813	1895	1614	1441
9.	Danish	Utah	10	49	55.4	3.0	1124	1678	1494	1432
10.	Siberian	Nevada	10	47	43.5	3.6	788	2064	1441	1431
11.	Garton No. 572	Idaho	10	48	50.1	3.0	663	2223	1340	1409
12.	Sparrow Bill	Utah	15	47	68.7	2.3	1124	1678	....	1401
13.	Wis. Ped. No. 1	Wisconsin	9	49	41.2	3.0	1060	1950	1161	1390
14.	Kherson	Colorado	12	41	31.6	2.5	1425	1658	994	1359
15.	Swedish Select	Montana	9	51	31.6	3.1	905	2837	1124	1355
16.	Colorado Black	Colorado	8	47	55.3	2.4	640	1975	1412	1342
17.	Wis. Ped. No. 5	Wisconsin	10	51	34.3	3.2	1103	1633	1265	1334
18.	Great Dakota	Colorado	8	50	33.6	3.1	1091	2008	898	1332
19.	Banner	Oregon	9	48	30.9	3.4	602	1944	1220	1255
20.	Colorado No. 37	Wyoming	9	50	44.7	2.6	935	1676	1127	1246
21.	Shadeland	Oregon	10	47	46.7	2.7	785	1707	....	1246
22.	Prince Royal		11	55	38.7	2.5	553	1737	....	1245
23.	Lincoln	Idaho	13	47	68.0	2.6	739	1736	....	1238
24.	Missouri Black	Missouri	10	48	41.6	2.5	403	2020	1275	1233
25.	Storm King	Washington	11	44	50.0	1.9	598	1743	....	1171
26.	Shadeland Challenge	Oregon	10	51	52.5	2.7	602	1690	....	1146
27.	Wyoming White Russian	Wyoming	11	48	57.0	2.6	1002	1280	....	1141
28.	Abundance	Nevada	10	51	36.1	3.0	692	1656	982	1110
29.	Minnesota Black	Minnesota	10	46	48.5	1.9	362	1767	....	1065
30.	Swedish Crown	Sweden	6	50	29.8	6.0	....	....	875	875
31.	Sixty Day	Utah	11	41	31.4	1.3	695	943	....	819
32.	Swedish Victory	Sweden	6	50	30.9	4.0	....	....	792	792
33.	White Tartar	Utah	12	39	27.7	1.0	740	756	....	748
34.	Colorado Prows	Utah	13	50	31.8	1.6	513	432	....	473
35.	Black Tartar	Utah	8	40	27.6	1.0	647	143	....	390

These results show a marked increase in the production of the Early Mountain variety in 1916 over that of the previous year, the yield being 95 bushels per acre in 1916. The average production of this variety for the two-year period was 81.75 bushels per acre. This was the only variety not seriously affected by shattering of the seed due to blasting of the panicles before the plants had matured. With most of these varieties over one-half of the grain had shattered before the plants were ready for harvest.

A field of abundance oats

SOIL. Oats produced the largest yields of grain in Nevada on relatively moist soils. When sown on soils rich in fertility, the grain often lodged badly so that only a portion of the crop was raised. Oats are better adapted to comparatively poor soils than either wheat or barley. Oats require a cool, moist soil, thus early spring seeding is desirable.

CULTURAL METHODS. The seed bed should be prepared and the crop irrigated in a similar manner to wheat. The amount of seed to sow will vary with the preparation of the seed bed, the size of the seed and the method of sowing. In Nevada from 80 to 90 pounds per acre have given the best results when sown with a grain drill.

In treating oats with formalin for the prevention of smut, use one pound of formalin diluted with 50 gallons of water, and continue the treatment as outlined under wheat.

Best results have been obtained by harvesting oats when the grain is in the early dough stage, and a portion of the leaves are still green. If grain in this condition is properly shocked, it ripens and cures slowly without injury to the composition or yield and there

will be little shattering of grain. When used for hay, oats should be cut while in the milk stage and cured like any other hay crop.

CO-OPERATIVE VARIETY TESTS

Co-operative variety tests of wheat and barley were conducted in 1915 and 1916 by F. B. Headley, Superintendent of the U. S. Experiment Farm at Fallon. The following table includes the results.

YIELD PER ACRE

WHEAT pounds per acre				BARLEY pounds per acre			
Variety	1915	1916	Avg.	Variety	1915	1916	Avg.
Little Club	2730	3138	2934	Coast	2040	1766	1903
Reiti	2562	2910	2736	Kents	1435	1915	1675
Dicklow	2496	2538	2517	Hanchen	1548	1454	1519
Marquis	2340	2574	2457	Chevalier		1502	1502
Defiance	2310	2526	2418	Svanhals	1435	1402	1420
Sonora	2238	2460	2349	Nepal (hulless)	1219	1296	1257
Bluestem	2430	2244	2337				
Ghirka	2100	2172	2136				

Little Club was the highest producer of the wheat varieties with an average yield of 48.9 bu. per acre for the two years. Coast or what is commonly known as California Feed barley was the highest yielding variety of barley with 39.6 bu. per acre. The yield of 2934 pounds of Little Club Wheat was 54.2 per cent greater than the yield of 1903 pounds of the highest yielding barley.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Bulletin No. 90 February, 1918

POTATO CULTURE IN NEVADA

By

C. S. KNIGHT, B.S.,
Dean of the College of Agriculture, and Agronomist of the
Agricultural Experiment Station

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1918

1[45]

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. JAMES F. ABEL (1917–1921), Chairman	Reno
Hon. JAMES W. O'BRIEN (1915–1919)	Sparks
Hon. JOHN J. SULLIVAN (1915–1919)	Reno
Hon. B. F. CURLER (1917–1921)	Elko
Mrs. EDNA C. BAKER (1917–1919)	Sparks

OFFICERS

WALTER E. CLARK	President of the University
Mrs. LOUISE BLANEY	Secretary
CHARLES H. GORMAN	Comptroller

STAFF

SAMUEL B. DOTEN, M.A.	Director and Entomologist
EDWARD RECORDS, V.M.D.	Acting Veterinarian
JAMES EDWARD CHURCH, JR., Ph.D.	Meteorologist
C. ALFRED JACOBSON, Ph.D.	Chemist
CHARLES S. KNIGHT, B.S.	Agronomist
CHARLES E. FLEMING, B.S.A.	Range Management
STEPHEN LOCKETT, V.M.D.	Assistant Veterinarian
HARRY W. JAKEMAN, V.M.D.	Assistant Bacteriologist
MAXWELL ADAMS, Ph.D.	Consulting Chemist
PETER FRANDSEN, A.M.	Consulting Biologist
C. W. LANTZ, A.M.	Assistant Botanist and Horticulturist
FREDERICK W. WILSON, M.S.	Consulting Animal Husbandman
VERNER E. SCOTT, B.S.	Consulting Dairy Husbandman
Mrs. T. W. COWGILL, M.A.	Librarian
HESTER MAYOTTE	Secretary

LETTER OF TRANSMITTAL

RENO, NEVADA, February 15, 1918.

GOVERNOR EMMET D. BOYLE, *Carson City, Nevada.*

DEAR GOVERNOR BOYLE: In April, 1917, the Nevada Agricultural Experiment Station published Bulletin No. 87 entitled "Home Potato Patches," by C. S. Knight, Dean of the College of Agriculture, and Agronomist of the Agricultural Experiment Station.

The demand for this bulletin was so heavy that early in the year the edition was exhausted. As requests for copies are still received almost every day, it now seems advisable to republish.

A large part of the information contained in Bulletin No. 87 was derived from series of experiments included in Projects 1 and 2, Hatch Fund. To this we have added a considerable amount of general information needed by potato growers at the present time. We are, therefore, presenting the bulletin again in a more expanded form and under a new serial number.

In 1917 many tracts of over five acres of potatoes were grown on waste land not previously cultivated. For the benefit of growers of these larger patches information has been included on the use of potato machinery and the general care of larger crops.

Respectfully submitted,

S. B. DOTEN,
Director,

ACKNOWLEDGMENT

The author wishes to acknowledge his indebtedness for cuts used in this bulletin as follows:

Figure 2—H. A. Hyde, Watsonville, Cal.
Figures 4 and 8—Hoover Manufacturing Co., Avery, Ohio.
Figures 5 and 6—Wm. Stuart, Bureau of Plant Industry, U. S. Department of Agriculture.
Figure 7—Aspinwall Manufacturing Co., Jackson, Mich.
Figure 9—Bateman Manufacturing Co., Grenlock, New Jersey.
Figure 12—The John Deere Co., Moline, Ill.
Figure 13—Champion Potato Machinery Co., Hammond, Ind.
Figure 14—Dowden Manufacturing Co., Prairie City, Iowa.

CONTENTS

	PAGE
Introduction	9
Soils for Potatoes	10
Preparing the Ground for Planting	10
Liming Heavy Soils	10
Increase Production by Use of Manure	10
Irrigation Before Planting	11
Seed Potatoes	12
Seed Selection	12
Proper Storage of Seed Important	13
Treatment for Disease	13
Cutting the Seed	14
Sprouting the Seed	15
Greening Seed Potatoes	15
Rate of Seeding	15
Planting	16
Irrigation	17
Overirrigation and Poor Drainage	18
Cultivation	19
Thinning	20
Sorting for Market	21
Storing	22

POTATO CULTURE IN NEVADA

INTRODUCTION

Nevada made a wonderful showing in 1917 by an increase of more than 200 per cent over previous years in the growing of home potato patches and gardens, by utilizing back yards, vacant lots, and fields not previously cultivated. It has been estimated that over three million such gardens were grown last year by this Nation, producing more than three hundred million dollars in food products.

The planting of home potato patches was a new venture for many residents of the cities and towns in Nevada, and a few were unsuccessful with their crops. However, the increased knowledge of handling the crop, together with the Nation-wide success of the garden movement in 1917, gave a great stimulus to the beginner in planning for a potato patch this year with a determination to be successful. On

Fig. 1—Harvesting Potatoes on the Truckee Meadows. A Very Desirable Market Potato.

account of the still greater demand for food for export in 1918 the people of the Nation are called upon to give more consideration than ever before to the growing of home gardens.

The potato occupies an important place in the diet of our entire population. It is not a difficult crop to grow under irrigation, and requires much less attention than a variety of vegetables planted in the same area. It will thus be possible for a large number of people in Nevada, who cannot devote the time required for a vegetable garden, to plant small tracts of potatoes. By following the instructions included in this pamphlet the crop will be grown with the least possible amount of labor, and at the end of the season the family will have on hand a year's supply of potatoes.

SOILS FOR POTATOES

The potato requires a fertile mellow soil, either a sandy or clay loam, well supplied with organic matter. The cultivation is easier on the sandy loams, and the danger of overirrigation is less, although, when properly handled, the clay loams produce equally well. Soils rich in humus or vegetable matter are especially well suited to potato culture, thus no other staple crop grown in Nevada is so well adapted to old alfalfa land.

PREPARING THE GROUND FOR PLANTING

The ground should be cleared of all rubbish, such as rocks, bricks, boards, chips, and weeds, for, if turned under by the plow or spade, they will prevent the seed-bed from packing sufficiently for the uniform and rapid germination of the seed after planting.

The ground should be plowed or spaded at least 8 inches deep as soon as possible, care being taken not to work the ground when too wet, which is indicated by the soil sticking to the shovel or plow in turning. The same day the ground is plowed or spaded it should be harrowed or raked, and a coarse dirt mulch left on the surface. This coarse mulch prevents rapid evaporation, and after a rain is easily renewed. If a fine dirt mulch is made after spading or plowing, a heavy rain will pack the surface to such an extent that a new mulch is difficult to prepare. The ground should remain in this condition from 1 to 3 inches until planting time to furnish a firm seed-bed for uniform germination of the seed and rapid development of the young plants.

LIMING HEAVY SOILS

Much of the soil in Nevada is heavy clay that is prepared for crops and cultivated with some difficulty; also, when the proper hoeing and cultivation is not given, the results are often unsatisfactory. This objection can be largely overcome by applying gypsum when preparing the ground for planting. Two methods may be used to apply the gypsum. If the ground is to be spaded by hand, the gypsum can be spread over the area quite uniformly with a shovel, and when the ground is spaded the lime is turned under with the inverted soil. If the ground is to be plowed, the gypsum may be applied with a shovel after plowing, and later covered by the harrow in the preparation of the seed-bed. Ten pounds of gypsum should be used for every 100 square feet of surface. This is at the rate of about two tons per acre.

INCREASE PRODUCTION BY USE OF MANURE

From the fact that considerable labor and expense is involved in the proper handling of a potato crop, the grower should aim to keep the soil in the highest possible state of fertility, by frequently manuring the land. The manure is best applied during the fall and winter months when the land is not growing a crop and preferably on land that is to be plowed before another crop is planted.

Every crop removed from the soil takes away certain materials that are essential in the growth of the plant. Soils will gradually decrease in their producing capacity when crops are grown continuously on the land without adding fertility. From the fact that about 40 per cent of the fertility removed from the soil may be recovered in the manure, one of the best means of maintaining the fertility of the soil is to return the manure to the land.

Manure to be most effective should be plowed under where its constituents will come in contact with the roots of the crop. Manure should not be covered so deep as to prevent fermentation. On clay soils the covering should not be over four inches, while with sandy soils a six-inch covering is not considered too deep.

Heavy applications of manure during dry seasons may result in a physical injury to the soil, due to a lack of moisture to cause the organic matter to decay. For this reason it is a good plan to irrigate the ground in the fall before applying the manure and plowing or spading it under.

Fresh manure may be injurious to potatoes, as it tends to produce scabby, undesirable tubers. For this reason in manuring land for this crop well-rotted manure should be used.

The amount of manure to apply depends upon the kind of soil and the quality of manure. Generally about 50 pounds for every 100

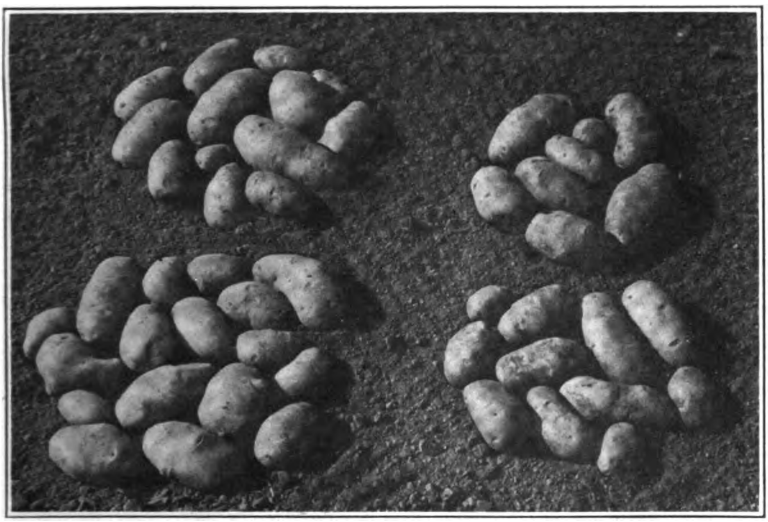


Fig. 2—Hill Selection versus Bin Selection:
Hill Selection—Average Weight of Two Hills Shown on Left, 5 pounds.
Bin Selection—Average Weight of Two Hills Shown on Right, 3 pounds.

square feet or 10 tons per acre is considered a good average application for ordinary farm crops, while 20 tons per acre is often not considered excessive for light sandy soils in the production of potatoes. Usually when such heavy applications are used, the manure is well rotted. Too liberal applications of manure are often wasteful, and better results are generally realized by the use of frequent light applications.

IRRIGATION BEFORE PLANTING

If irrigation is necessary before planting, it should be given before the ground is spaded or plowed. The coarse dirt mulch left on the surface by the rake or harrow retains sufficient moisture in the soil for sprouting the seed and for the early development of the plant. An irrigation after spading would cause the soil to pack too much and a second spading would be required.

SEED POTATOES

The Experiment Station has tested a number of varieties of potatoes during the past five years, with the result that Great Divide, Burbank, and Peerless were the highest average producers, in the order named. These varieties have been grown in Nevada for many years and indicate the value of well-selected home-grown seed as compared with that introduced from other States. The Netted Gem, commonly called the "rough-skinned Burbank," is advancing in popularity in several potato districts of Nevada.

A small amount of seed was grown in 1917 of each of nine leading varieties of potatoes which are being tested in different Western States under irrigation, the object being to obtain a sufficient amount of seed for a test of these varieties in 1918 in comparison with our present high producers. Included in this list are Producer, White Rose, American Wonder, Pride of Multnomah, Earliest Fall, Snow (California), Early Prize Taker, Scotch Rose, and Snow (Oregon).

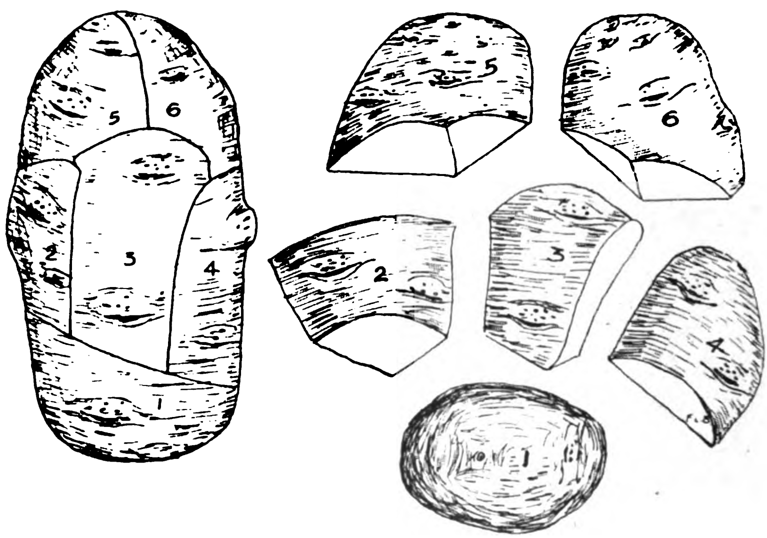


Fig. 3—A Potato weighing 10 to 12 ounces properly cut for seed.

SEED SELECTION

The most successful method of securing seed potatoes is to go through the field at digging time and dig the strongest plants that appear most productive. If the hill has the proper number of uniform-shaped tubers that are free from scab or other disease, the potatoes from this hill should be saved for seed. By this method in a very short period of time the farmer, with the help of two or three boys, can obtain excellent seed for planting the following year. This method is more expensive than getting seed from storage, but the increased production the following year pays many times for extra labor involved in gathering the seed.

For this reason the seed should be secured in the fall when the grower has the opportunity of knowing how the potatoes were grown and that they were properly stored through the winter months so that their germinating power has not been impaired.

PROPER STORAGE OF SEED IMPORTANT

Seed potatoes should be so stored that they will remain dormant during the winter. Potatoes that have been affected by chilling or heating during the period of storage will not produce a perfect healthy stand when planted the following spring. During storage of potatoes in Nevada the past winter, heating followed freezing in many cases. In some instances the freezing was so severe that decomposition of the tissue took place, causing the starch to change to sugar. This seriously impaired the vitality of the seed, and led to the poor weak development of potatoes in many of our fields the past season.

Growers may realize good crops of potatoes from seed taken from the general lot in the spring, but a marked increase will be noted in

Fig. 4—A Machine used in cutting large quantities of Potatoes for Seed.

the production of good uniform potatoes when the seed is obtained by the method of hill selection from the field in the fall.

TREATMENT FOR DISEASE

The following treatment is recommended for the prevention of scab and other diseases: All seed potatoes should be soaked in a solution of mercury bichloride (corrosive sublimate), 4 ounces in 30 gallons of water, for one and one-half hours. Formalin treatment will not kill *rhizoctonia* as completely as mercury bichloride. The solution should be placed in a wooden barrel or tank. It corrodes metal. It should be

poured out and made up fresh after it has been used to disinfect four lots of potatoes. It is poisonous if eaten, but is not poisonous to the touch. Treated potatoes should not be eaten or fed. After the potatoes have been treated, they should be stored in new sacks which have been similarly disinfected in the solution.

The formalin treatment is as follows: Prepare the solution by adding one pint of 40 per cent formaldehyde to 30 gallons of water. Place the sacks of potatoes in the solution and leave submerged for two hours. After removing from the solution the potatoes should be dried, cut and planted. However, if stored for a short time, they should be returned to the same sacks which have been disinfected by the solution.

CUTTING THE SEED

The potatoes should not be cut in pieces less than one ounce in size, and the best crops will be obtained where the pieces are from one and one-half to two ounces. The seed piece should have two good eyes.

Fig. 5—Excessive Sprouting saps the vitality of the Potato for Seed.

Where more than this number of eyes is present or where larger pieces are used, the soil must be very fertile and the seed pieces must be planted farther apart in the rows, otherwise the percentage of small tubers may be too great.

A good method to follow in cutting the seed is to begin cutting from the stem end, diagonally across the potato, being careful to cut the seed end so that too many eyes are not left in one piece.

The seed should be planted not later than the day after being cut. If exposed to warm windy weather for any length of time, too much moisture may be lost and the seed may be injured by excessive drying.

A common practise in Nevada is to place the cut seed loosely in the disinfected sacks and store for a time in a well-ventilated place, being careful not to stack the sacks in a large heap. This often injures the

seed by causing it to turn black before the moisture has evaporated from the cut surface.

SPROUTING THE SEED

Certain growers in Nevada have used the method of sprouting the seed where early potatoes were desired. The general method followed consists in placing the potatoes on a clean floor about six inches deep, where they have access to the light, for about a month. The potatoes are turned every few days in order to obtain uniform sprouting. When the potatoes are handled carefully by this method, very little injury is caused by the breaking off of the sprouts and excellent results are realized.

GREENING SEED POTATOES

This practise consists of removing the seed potatoes from storage in the spring before sprouting has commenced, spreading them over a clean area in a layer about 6 inches deep, and exposed to the light, and

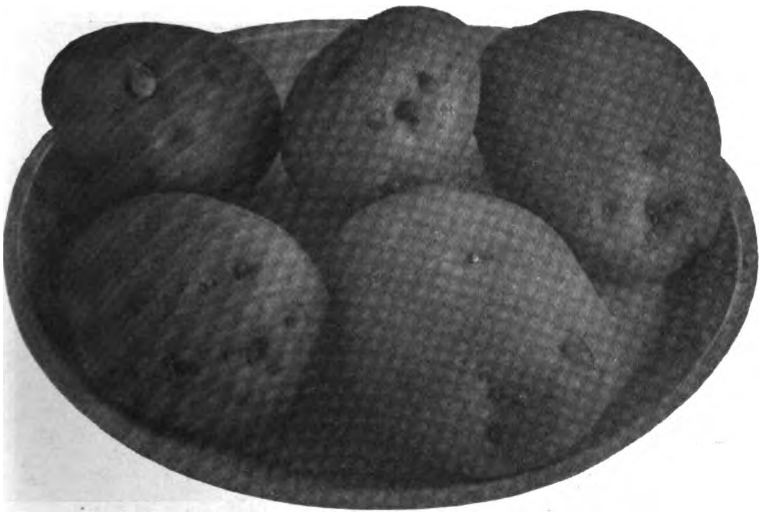


Fig. 6—The Ideal Stage of Sprouting for the Seed Potato.

turning them about every ten days. This treatment produces a green tough skin which is not easily rubbed or broken. It has been used in preference to the corrosive sublimate or formalin treatment by the Colorado Station in the prevention of disease. This practise is not common in the potato districts of Nevada.

RATE OF SEEDING

Where one-ounce seed pieces are used, the potatoes should be planted in rows 3 feet apart and about 15 inches apart in the row. With two-ounce seed pieces the distance apart in the row may be 18 inches.

The amount of seed required per acre with different sized seed pieces is shown in the following table:

Weight, ounces	*Pounds of seed 15 inches between hills*
1.0	720
1.5	1,080
2.0	1,440

PLANTING

In most parts of Nevada the late potatoes are planted between May 1 and 20, usually about 4 or 5 inches deep, on land spaded or plowed at least 8 inches deep before the 1st day of May.

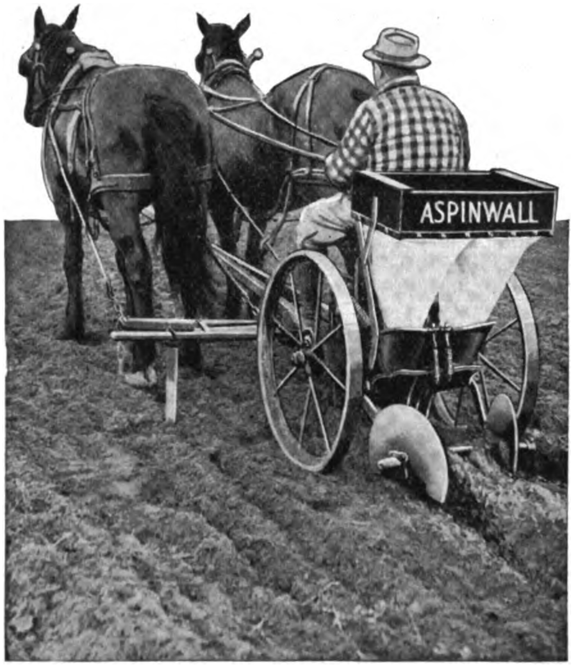


Fig. 7—A One-man Potato Planter. The Seat is located in front of the Seed Hopper.

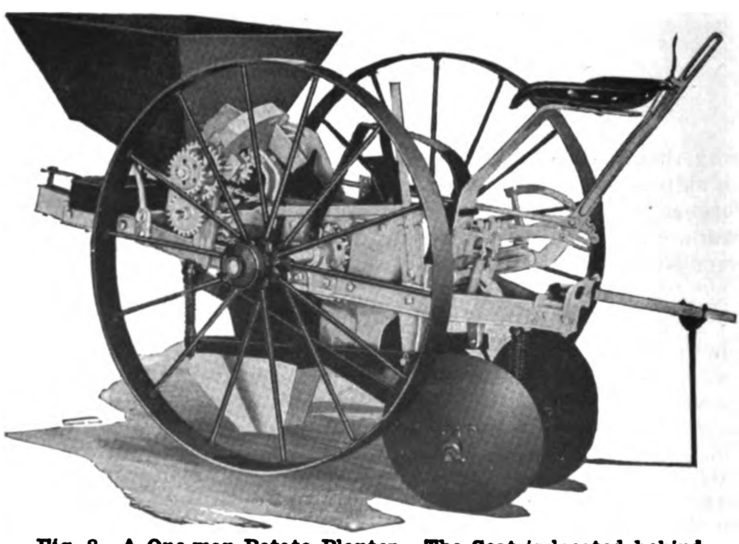


Fig. 8—A One-man Potato Planter. The Seat is located behind the Seed Hopper.

On small tracts a common method of planting is to plow the land shallow and drop the seed in every third furrow. A large number of the home potato patches, however, will be too small for the use of the plow, in which case the planting may be done with the use of the shovel or hoe. On the small tracts it is advisable to mark out the land in checks, so that the hills of potatoes will be uniformly spaced.

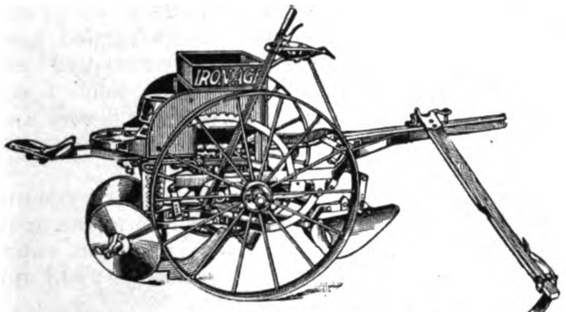


Fig. 9—A Two-man Potato Planter.

IRRIGATION

The potato rows should be hilled up with good deep furrows between them, so that, when irrigated, the water will supply the deep-feeding roots, but will not come in contact with the tubers.

Fig. 10—Irrigating a Field of Nevada Potatoes

A too common error with the potato grower is the use of shallow furrows for carrying the water. The chief danger is in saturating the ground around the tubers, causing the soil to become hard and compact, a very undesirable condition for the development of a good hill of uniform potatoes. It is thus very important to use light irrigations in good deep furrows.

In irrigation experiments with potatoes conducted at the Experiment Station, the results of the test for the past four years favor the 3-inch irrigations as compared with 6- and 9-inch applications. The most practical results were obtained with six 3-inch irrigations, or a total of 18 inches of water, given when the plants showed a tendency to wilt.

In the irrigation of potatoes, the best results were obtained when the first irrigation was withheld until the plants turned a darker green color, but had not wilted. This condition permitted the greatest possible root development to supply the necessary food for a maximum crop. Early irrigation, before the plants showed any need of water, greatly retarded the proper development of root system, and resulted in a decreased yield of potatoes.

After irrigation had started, it was found very essential never to allow the plants to suffer for lack of water during the growing season. Where any plants wilted slightly after irrigation commenced, the growth of the plant was greatly checked, and the yield and quality of the tubers were seriously affected.

The potato crop should never be irrigated by means of flooding or surface sprinkling, since both methods cause the soil to pack around the tubers and prevent the ground from receiving sufficient water for the need of the plants. All water applied to the potato crop should run in small streams through deep furrows made between the rows of potatoes.

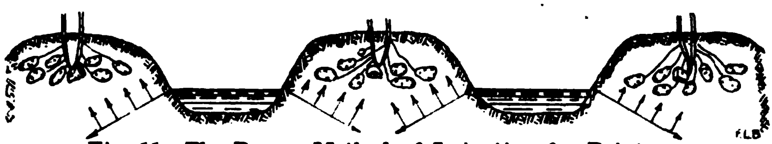


Fig. 11—The Proper Method of Irrigation for Potatoes.

OVERIRRIGATION AND POOR DRAINAGE

The potato crop is very sensitive to an excess of moisture in the soil. Most of the failures in potato growing in this State have occurred on the heavy lands, and have been due chiefly to this one cause. Soils which contain an excess of water are too cold for the proper development of the potato and offer conditions favorable to the formation of scab and rot. Most of the soils on the Experiment Station Farm are too heavy and too level for good results with potatoes. It is noted above that the most practical method of irrigation was by the use of light applications when the plants had turned dark-green in color. At the time of harvest this ground turns up in large clods unless irrigated immediately before digging. This condition indicates that the ground has packed too firmly for the proper development of uniform marketable potatoes. Such lands are made more porous by a heavy application of lime or gypsum, but the potatoes are liable to be badly affected with scab, as is the case when fresh manure is used in large quantities. Many growers overcome this objection on heavy soils by planting the potatoes on land with a considerable slope. Here the drainage is good and there is less danger that the soil will remain too wet.

For the best results with potato growing, well-drained land is essential, and only moderate applications of water should be given the crop when needed.

CULTIVATION

Cultivation should be given after each irrigation until the plants are so large as to be injured by the horse or cultivator. Cultivation is just as important as irrigation for success in potato culture, since it thoroughly aerates the soil, keeps down the weeds, helps to retain moisture in the soil and maintains a good deep furrow for irrigation. The soil should be kept in a moist condition until the potatoes are fully

Fig. 12—A Walking Potato Digger, commonly used by the small grower in Nevada.

grown. In most of the potato districts of Nevada, irrigation will generally cease from August 15 to 31, varying with the season and time of planting.

Practically all cultivation on the home potato patches will be given with a hoe. Even though weeds are not present to any great extent, cultivation with the hoe is still very important in order to keep the soil

Fig. 13—One Type of Sulky Potato Digger used in Nevada.

in a loose mellow condition around the tubers. The most important reminder for the potato-grower is to eradicate all weeds while still small. If weeds are allowed to grow for several weeks, they are not only removed by the hoe with considerable difficulty, but they also drain the soil of moisture and plant-food which should be utilized by the potato plants for a maximum production.

THINNING

The thinning of potatoes grown under irrigation has not been practised with any degree of success where tried in Nevada. The object of thinning is to remove the less thrifty stems and to establish unifor-

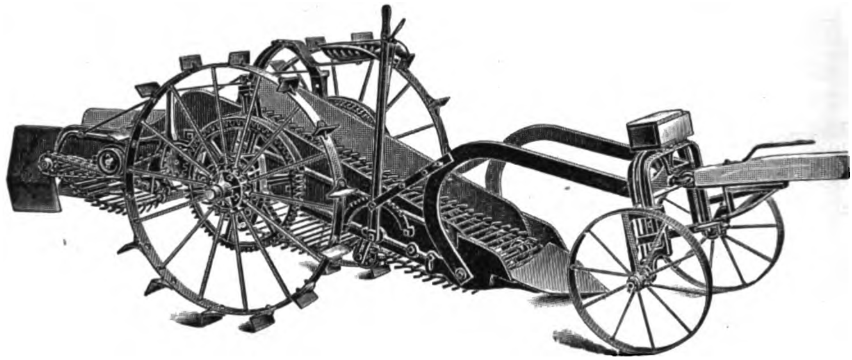


Fig. 14—Another Type of Sulky Potato Digger used in Harvesting Nevada Potatoes.

mity in the number of stems per hill. The Montana Station conducted experiments in 1913 and 1914 on the thinning of potatoes, and, with the Burbank variety planted 12 inches apart in the rows, the yield of marketable potatoes was over 20 per cent higher for the unthinned potatoes than for those which were thinned.

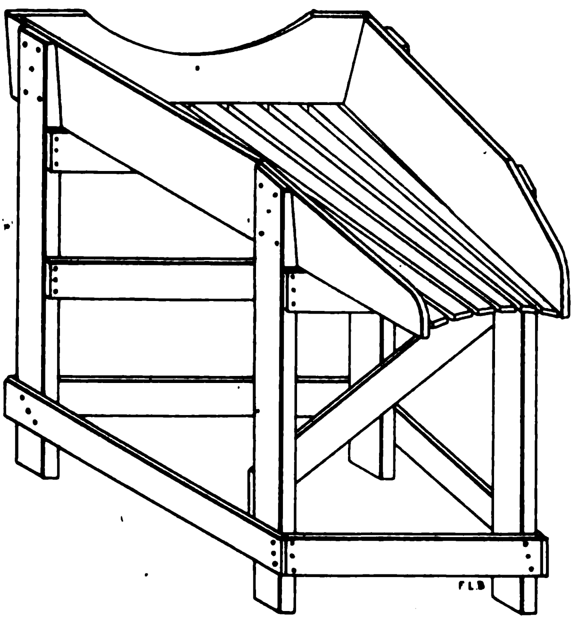


Fig. 15—A Simple Type of Hand Potato Sorter.

The thinning of potatoes is not to be recommended for Nevada growers, and where seed pieces are used with not more than two or three

good strong eyes, little trouble is encountered in producing too many stems to the hill.

SORTING FOR MARKET

The demand for a more uniform potato that is free from disease and blemishes has caused a number of Nevada growers to sort or grade their potato crop before marketing. For small lots an ordinary hand sorter is very effective. This consists simply in an inclined table with slats to allow the dirt to fall through, and with the lower side open so that the market potatoes can pass into the attached sack. This is not a very long or difficult process, and it adds greatly to the market value and keeping quality of the potato. The culls may be used on the farm as a succulent feed for dairy cattle or hogs.

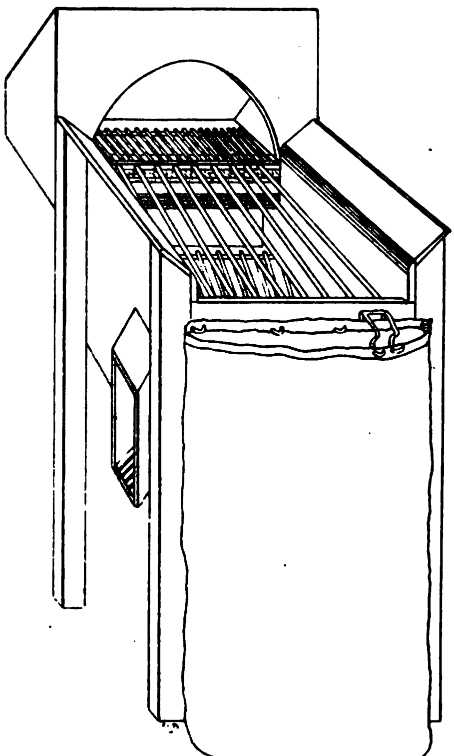


Fig 16—A Potato Sorter showing Sack Attachment for Market Potatoes.

The standard market grades as now established in the United States are as follows:

No. 1—Potatoes over 1⅞ inches in diameter for the round varieties and 1¾ inches in diameter for the long varieties. Less than 5 per cent shall be undersized, and an additional 3 per cent is allowed for injured potatoes.

No. 2—Potatoes over 1½ inches in diameter and not more than 5 per cent undersized. An additional 5 per cent is allowed for injured potatoes.

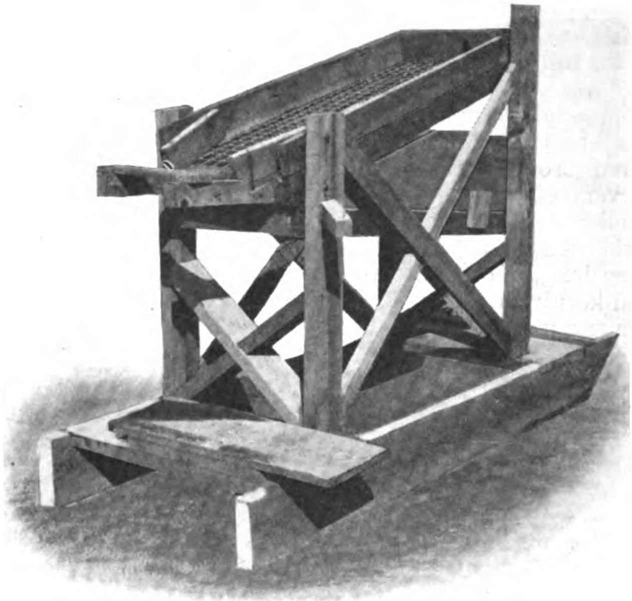


Fig. 17—A Home-made Sled Potato Sorter used in the Truckee Valley. One man with this Machine follows five pickers in sorting and sacking the potatoes ready for market.

STORING

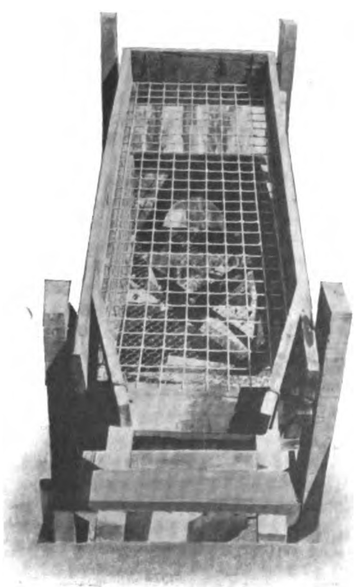


Fig. 18—Another View of the Home-made Sled Potato Sorter.

On account of the severe winters, which occur in Nevada from time to time, growers should provide storage facilities for their crops that the tubers may not be injured by freezing or heating. Both the cellar and the ordinary field pit may be used successfully for this purpose. In Bulletin 79 of the Idaho Experiment Station, the following information is given concerning potato cellars, which is very applicable to Nevada conditions:

In a dry well-drained location a pit four feet deep and any width and length to accommodate the needs should be dug. A knoll is preferable to a side hill. It may be stated that a cubic foot will store approximately forty pounds. The studding for side walls may be posts set firmly in the ground and should rise a foot above the surface of the ground. The roof need not have greater than one-fourth

pitch. It may be built of round poles or 4x4-inch timbers for the rafters and covered with stock lumber. Ventilators 10x10 inches are necessary every sixteen feet in the ridge. The whole structure is now ready for the final covering, and it may be started with eighteen inches of straw and then six to eight inches of the soil which was removed from the pit.

Where large amounts are to be stored the cellar should be wide enough to permit of a driveway. There need not be a door at each end, although that is better. Where the crop is stored in sacks a floor is necessary, as sacks will rot if put in contact with the soil. This floor may be slatted, as this will facilitate ventilation.

The temperature for best results should be but two or three degrees above the freezing-point, 34°F. being ideal. This temperature should be maintained as nearly as possible. With some attention this is simple. Where the nights of spring and fall are cool, as in almost all parts of the State, the opening of doors in the evening and closing early in the morning after the crop is put in will soon reduce the temperature to the standard. It can be maintained quite closely by the judicious use of the doors throughout the storage season.

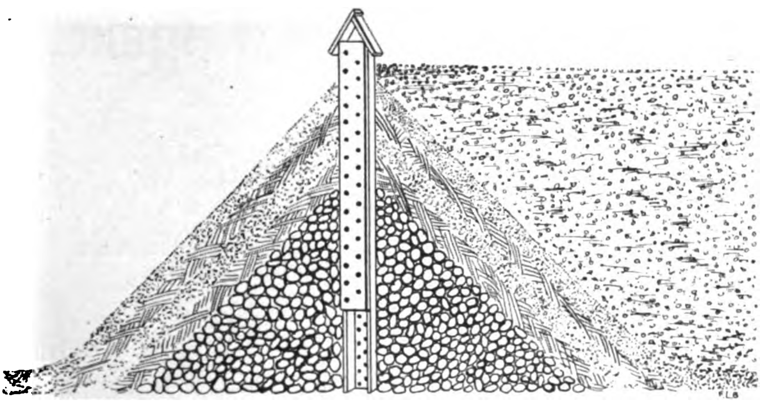


Fig. 19—A Potato Pit used in storing a large portion of the Nevada Potato Crop.

Much of the Nevada potato crop is stored in field pits, which are located on high land in the field where good drainage is possible. The bulletin on Nevada Potatoes, by C. A. Norcross, describes in detail the storing of potatoes in pits as follows:

Having chosen a site for a pit, scrape off about six inches of the top soil, and form a ridge about the base of the proposed pit, which should be about four and one-half or five feet wide by sixteen or twenty feet long. Tramp the bed so it is as hard and firm as possible and smooth it. The potatoes are poured into this open pit on the dirt and piled to a triangle point or ridge, the length of the pit. When so piled, cover the potatoes with dry potato vines or straw so that when compressed the mat will be three or four inches in thickness. Over this layer of vines or straw throw a six-inch layer of dry dirt, leaving two or three openings at the top of the pit for the escape of heat and moisture. Pat the outside of the dirt covering with the back of a shovel until it is firm and smooth so that rain will run off rather than percolate.

Next, dig a drain around the pit and leading away from it, and the first stage of the pit is completed. After a week or so close the openings left for

ventilation. Before freezing weather commences in earnest add a foot or more of soil to the pit covering, pat it down, and see that the drainage ditches are open. The depth of the final soil-covering varies in different sections, and the experience of local farmers is the best criterion.

Pits should be located north and south, rather than east and west, in order to render uniform the sunshine on both slopes. When placed east and west the north slope is usually damper than the other and is slower to thaw in the spring. The sunshine, while it warms the sides, also evaporates the moisture, rendering a north-and-south pit drier than one that is east and west.

For further information on potato culture, address

DEPARTMENT OF AGRONOMY,
University of Nevada,
RENO, NEVADA.

TYPOGRAPHICAL UNION LABEL WASHOE

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

BULLETIN No. 91—FEBRUARY, 1918

Silage Crops for Nevada

BY
C. S. KNIGHT, B. S.
DEAN OF THE COLLEGE OF AGRICULTURE AND AGRONOMIST
OF THE AGRICULTURAL EXPERIMENT STATION

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

PRESS OF GREEN & LAKE, INC., RENO
1918

NEVADA AGRICULTURAL EXPERIMENT STATION

TABLE OF CONTENTS.

SILAGE CROPS IN NEVADA—Introduction........................ 3
- Corn 3, 4
- Russian Sunflower 5, 6
- Sudan Grass 6, 7
- Wheat 7
- Millet 8
- Field Peas and Oats........................ 8, 9
- Alfalfa 10
- Sweet Clover 10
- Sorghum (Non-saccharine)........................9, 10
- Russian Thistle 10, 11

ROOT CROPS FOR SUCCULENCE........................ 11
- Sugar Beets and Mangels........................11, 12
- Beet Top Silage........................ 12

FILLING THE SILO........................12, 13
SILAGE AS A LIVESTOCK FEED........................ 13
SILOS FOR NEVADA........................ 13
CONCRETE AND STAVE SILOS........................ 14
PIT SILO 15
AMOUNT OF SILAGE REQUIRED........................ 16
CAPACITY OF ROUND SILOS........................ 16

SILAGE CROPS FOR NEVADA

INTRODUCTION.

Not until the past two years has any serious consideration been given to the problem of introducing silage as a part of the feed ration for farm and range livestock. The reason for this was that first-class alfalfa hay was always available to the feeders at a price varying from five to ten dollars per ton. Since the price of hay and grain has practically doubled in Nevada the farmers and ranchers are now forced to consider seriously the growing of some cheap succulent roughage to supplement these high-priced feeds for fattening and wintering the livestock.

In Nevada, where so many of the livestock are fed alfalfa hay during the winter months, the use of silage, low in protein and relatively high in carbohydrates, prevents to a large extent the digestive troubles of cattle caused by the continuous use of the high-protein alfalfa hay.

Silage contains about 70 per cent of water at the time it is fed, thus furnishing a succulent feed that keeps up the quantity of milk during the winter period, which is impossible on dry feeds alone. Where silage is used as a part of the dairy cow ration, more animals may be kept on a given area of farm than otherwise, due to the exceptionally heavy yields of forage that are possible with crops like corn and Russian sunflower.

In previous years many stockmen considered that the growing and feeding of silage was not a profitable undertaking with an adequate supply of other desirable cheap feeds available. The time has come, however, when the silo is to be closely associated with profitable dairying and livestock feeding in this state.

SILAGE CROPS.

A number of crops adapted to the soil and climatic conditions of Nevada are especially well suited for silage purposes. In some localities certain of the crops mentioned will do better than others in this connection, and the discussions which follow cover to a large extent the comparative value of these crops and the methods of culture for the best results under the different conditions in the State. The most important silage crops for Nevada are corn, Russian sunflower, Sudan grass, wheat, millet, field peas and oats, sweet clover, alfalfa, sorghum, Russian thistle and sugar beet tops.

CORN.

Corn is the crop generally grown for the silo. Corn silage and alfalfa hay make a good balanced ration and the ensilage provides a succulent and very palatable food when needed

Experiments conducted for a period of four years with eleven hardy northern varieties of corn show the following average results:

A Heavy Crop of Silage Corn Grown in Clark County.

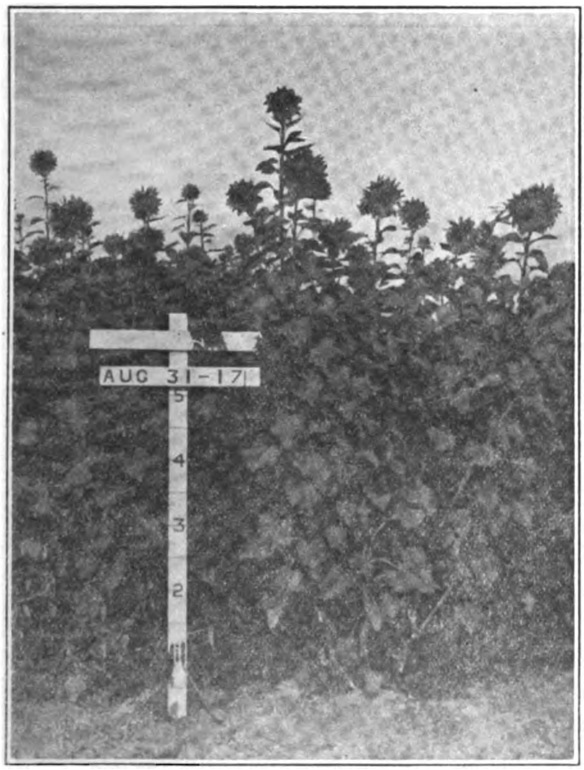
AVERAGE YIELD PER ACRE OF ENSILAGE, POUNDS, 1913-1916.

Variety	*Pounds per Acre*
Improved Leaming	22,570
Sweepstakes	21,955
Colorado Yellow Dent	19,944
Disco 90-Day Seed Corn	19,746
Pride of Minnesota	19,247
Swadley's Field Corn	18,871
Sure Crop	18,669
Huron Dent	18,593
Minnesota No. 13	18,532
Pride of the North	17,408
Wisconsin Yellow Dent	17,067

In these tests the seed was planted between the 15th and 20th of May with a hand corn planter about three inches deep and from 20 to 30 inches apart in the row. Furrows were made between the rows for the irrigation of the crop. During the four-year period the Improved Leaming variety was the highest producer with 11.3 tons per acre. In no year did any variety mature grain, but in most seasons certain types produced profitable crops of silage, which provided a very palatable and satisfactory feed for cattle and sheep when fed in connection with alfalfa. Each year a killing frost occurred between the 10th and the 20th of September, which stopped the growth of all varieties before the grain had matured; but in every instance the grain had reached the milk stage and in some varieties, the glazing stage. In most of the dairy districts of Nevada corn can be matured sufficiently to make a good quality of silage. The greater portion of the feeding value of the corn plant is in the grain. Therefore, when the grain fails to develop, the corn stalks alone can not be considered a good silage crop.

RUSSIAN SUNFLOWER.

The Russian Sunflower is especially well adapted to Nevada conditions and produces a very heavy yield of silage. This is a single stalk variety which develops a large head about seven inches in diameter. The seed is planted about two inches deep in a similar manner to corn between the middle of May and the first of June in rows about three feet apart and from four to eight inches apart in the row. When grown for seed about 12 inches should be left between plants in the row. The crop is irrigated and cultivated like corn, and is harvested for ensilage when the seeds have developed to the late milk stage but before they have been taken by the birds. Where birds are troublesome, the crop should be cut when in the early milk stage and placed in the silo. A small area of this crop may be cut successfully in a comparatively short time with the ordinary corn knife or sharp hoe with a short handle. In harvesting large areas the corn harvester will be found effective.



Russian Sunflower produces about twice as much Silage as Corn in Nevada and has an Equal Feeding Value.

The sunflower is ready for harvest by the first of September and thus can be cut green and placed in the silo before any injury is caused by a killing frost. In this respect it excels corn for ensilage, as corn is sometimes seriously injured by a killing frost before it has reached the proper stage of development for silage.

The corn grown at the Reno Experiment Station reaches the proper stage of maturity about the middle of September.

In our experiments with the Russian sunflower last year the crop yielded over 23 tons of silage in comparison to about 14 tons of corn silage in the same experiment.

After harvesting the sunflower was cut into pieces about ¾ of an inch long with an ensilage cutter and placed in the silo. Later it was fed in connection with alfalfa hay and rolled barley to the University Dairy Herd with excellent results. The coarse stems and heads, including the seed, went through the proper stages of fermentation and worked up into a mealy, succulent pulp which was very palatable and was entirely consumed by the stock.

Recent investigations by the Montana Station comparing Russian sunflower and corn silage where an average of over 70 pounds of each silage were consumed daily per head, show that the sunflower silage, pound for pound, was about equal to the corn silage as a feed for dairy cows.

Sudan Grass grows especially well in Nevada.

SUDAN GRASS.

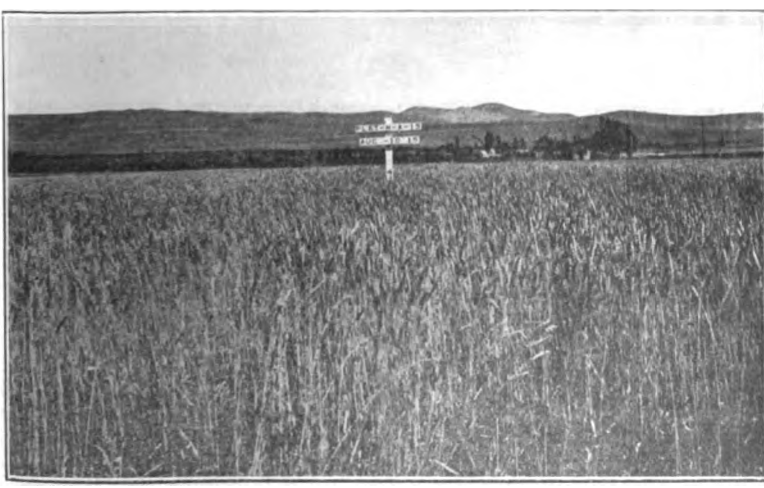
Sudan grass is an annual forage crop which belongs to the sorghum family and somewhat resembles millet in habit of growth. It attains a height of from five to seven feet, is not a

difficult crop to grow in Nevada and produces an abundance of forage.

Sudan grass will grow on all well-drained soils of Nevada, although like most other crops it produces the best results on the fertile loam soils. When planted in rows and given continuous cultivation, this crop will withstand considerable drought. The planting must be delayed until the danger of late spring killing frosts has passed. At the Experiment Station the practice has been to sow from the 15th to the 25th of May. If the crop is to be grown for forage the seed may be broadcasted or sown with a grain drill not over one and one-half inches deep at the rate of about twenty pounds to the acre.

In most agricultural sections of Nevada as at the Experiment Station, only one crop of Sudan grass is possible, and the crop is best cut for silage when the seeds have reached the milk stage, in the latter part of August. The crop is harvested like alfalfa, is run through an ensilage cutter and placed in the silo. The silage is highly relished by dairy cattle and makes a very desirable combination with alfalfa hay as it is relatively low in protein and well supplied with carbohydrates. Sudan grass should be used for pasture with considerable caution on account of the danger of poison to stock from the prussic acid contained in the immature plants.

The results of tests at the Experiment Station show that Sudan grass will produce on an average of from 7 to 10 tons of silage per acre.



Marquis Wheat Producing Seven Tons of Silage per Acre.

WHEAT.

The wheat plant makes a very palatable and nutritious silage, and is used extensively for this purpose by the dairymen of the northwest. The crop is grown similar to wheat raised for seed, and is cut for silage when it has reached the late milk stage. Farmers generally are very familiar with the require-

ments of wheat and for this reason grow it in preference to other higher producing forage crops. The Experiment Station has produced an average yield of from 5 to 7 tons of wheat silage per acre. The wheat was planted during the month of April with a grain drill, at the rate of from 75 to 90 pounds of seed per acre. On very fertile ground the heavier seeding is recommended when the crop is grown for silage.

MILLETS.

The millets do not grow well until the hot weather approaches, but if planted by the first of June they will mature a good silage crop in about ten weeks. They are decidedly drought resistant and will grow well in regions of slight rainfall. Millet does better on the sandy loams than on the heavy clays. Since the seed is small, the ground should receive about the same preparation as when fitted for seeding to alfalfa. The plant has abundant feeding roots and will grow fairly well on poor soil.

Millet Varieties grown for Silage at the Experiment Station.

The same method of seeding may be used as for alfalfa. Twenty-five pounds of good seed to the acre is sufficient, but with inferior seed twice this amount may be required. The crop should be cut for silage when the seed has reached the milk stage, using the same methods of harvesting as with alfalfa. The results of tests with millet varieties at the Experiment Station show the Siberian and Hog varieties to be our best producers, yielding from 6 to 8 tons of silage per acre. The silage is very similar in palatability and feeding value to Sudan grass silage.

FIELD PEAS AND OATS.

In growing field peas and oats for silage it has been found a good practice to plant the peas about two weeks earlier than

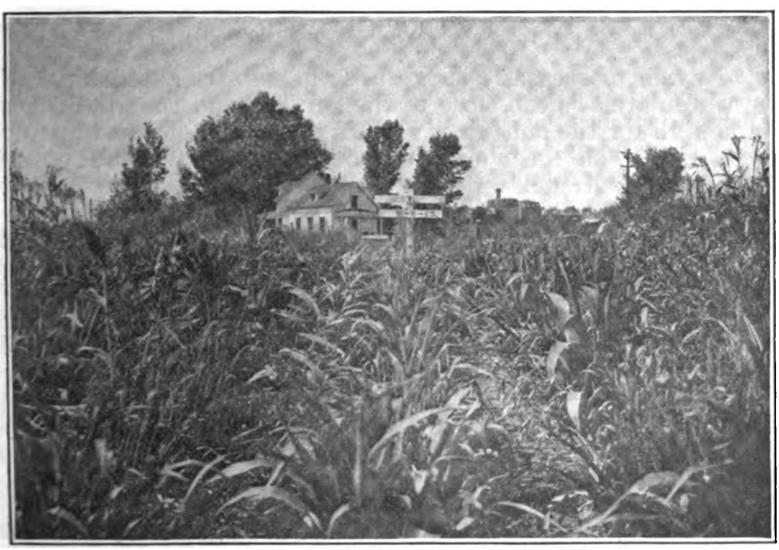
the oats, drilling the peas to a depth of from two to three inches. In this way the two crops make a more even growth, and the peas are not stunted by the rapid early growing oats. Usually both crops are planted with a grain drill, closing every alternate drill hole for the peas, and using about 1½ bushels of seed of each crop. This crop is not so well adapted for silage as those previously mentioned. We do not consider oats well suited to the climatic conditions in Nevada, as the heads are often seriously blasted and checked in growth during the early formation of seed. This combination has produced an average yield of from 5 to 7 tons of silage per acre in tests at the Experiment Station.

SORGHUM.

An experiment with varieties of non-saccharine sorghum was carried on for a period of two years. Although the yields of green forage were about the same as those of the corn varieties, the plants made such a slow early growth that no grain was formed during either year. The average results for the two years are included in the following table:

AVERAGE YIELD PER ACRE OF SILAGE, POUNDS, 1914-15.

Variety	*Pounds per Acre*
Red Kafir Corn	21,736
Dwarf Black Hulled Kafir	18,149
White Kafir Corn	18,098
Broom Corn	16,937
Feterita	16,220
Yellow Milo Maize (Dwarf)	14,839
Broom Corn (Oklahoma)	11,179
Jerusalem Corn	7,675
Shallu	5,612



Sorghum Varieties grown for Silage at the Experiment Station.

In this test the seed was planted between the 15th and 25th of May in rows three feet apart and about two inches deep. The crop was irrigated in the same manner as corn. The Broom-corns advanced the most toward maturity. Although the growth was checked each year by a killing frost early in September, a uniform crop of excellent heavy brush was formed with two varieties of Broom-corn. During the years 1914 and 1915, the Red Kafir and the Dwarf-Black-Hulled Kafir were the highest producers with 21,736 and 18,149 pounds of forage per acre respectively. The greater portion of the nutriment of the sorghum plant is in the grain, and since no grain was formed on the varieties of Kafir or Feterita, these crops are not considered so valuable for silage as corn. In certain agricultural districts of Nevada the sorghum will mature a grain crop, but the greater production of grain and higher feeding value gives the corn crop the advantage for ensilage.

Feeding experiments conducted at the South Dakota Station show that, pound for pound, corn silage is nearly twice as valuable as sorghum silage in producing livestock gains. Sorgum is not to be recommended as a silage crop in Nevada where corn can be grown successfully.

ALFALFA.

The results of investigations at the Experiment Station in the feeding of alfalfa silage to cattle and sheep show that such a practice is not profitable where first quality alfalfa is used. Where the quality of hay is injured by frequent rains after cutting or by frost early in the summer the alfalfa can be profitably handled as silage and in this condition maintains practically its full value in nutrients. Alfalfa silage should be used if possible before the first of the year in order to realize the full feeding value.

SWEET CLOVER.

Nevada possesses a large area of sub-irrigated land where the water table is too close to the surface and the alkali content is too high for the culture of alfalfa and many other staple crops. Sweet clover has been found to be especially well adapted to a large portion of such lands, growing with little or no irrigation, the water table being close enough to the surface to supply the needs of the crop. Sweet clover is now found growing wild on ditch banks and in low places throughout the State, which is a good indication of its suitability.

White sweet clover is the variety found growing commonly in Nevada. It lives for only two years. The crop is cut for silage when the plants are about one-third in bloom. It makes good silage for cattle and sheep and in this form the entire crop is utilized; still, the use of this crop for ensilage is to be recommended only when conditions prevent its proper curing and handling for hay.

RUSSIAN THISTLE.

The Russian thistle is a noxious weed widely distributed in Nevada. It should never be planted as a silage crop or for any

other purpose. Only in those districts where it is found growing abundantly as a weed and where there is a shortage of other silage crops is it recommended that the Russian thistle be used. The feeding value of the Russian thistle has been estimated to be about fifty per cent of that of good alfalfa hay.

Mr. E. R. Mackay of Fallon who has used Russian thistle silage as a livestock feed, states that:

"The Russian thistle is the most serious weed pest on the Truckee-Carson project. It will grow everywhere, where land is not cultivated, under irrigation and on the higher lands where the water does not reach it. Last year we experienced a shortage of crops to fill the silo, so decided to use the Russian thistle. The thistles were cut with a mowing machine the last of August just as the spines were forming on the plants, and placed in the silo at a total cost of $1.65 per ton. Salt was added according to judgment as the silo was being filled.

"We started feeding the silage to steers at night with eight pounds per head daily, gradually increasing this amount to 20 pounds for each feeding. The value of the silage is estimated at $7.00 per ton. It is highly relished by the stock which are showing much better gains than those fed on alfalfa alone."

ROOT CROPS FOR SUCCULENCE.

On account of the high price of alfalfa hay many dairymen and stockmen who are not prepared to build silos are growing some form of root crop for succulence. The Experiment Station has conducted a series of tests with the different classes of root crops. The stock turnips, rutabagas, field carrots, parsnips, and swedes have been found undesirable on account of the serious insect pests which constantly attack these crops and prevent their successful development.

SUGAR BEETS AND MANGELS.

The beets and mangels are very well adapted to Nevada conditions and if given proper care will produce heavy yields of roots. A test was made on the comparative value of sugar beets, half-sugar beets and mangels for feeding purposes.

The beet varieties were planted during the month of April each year. The seed was sown at the rate of 12 pounds of mangels and 20 pounds of sugar beets per acre about one inch deep in rows two feet apart. The beets were thinned to one plant every 10 or 12 inches apart in the row.

The results show that under favorable conditions the mangel will produce about 30 tons per acre, the half-sugar beet 20 tons and the sugar beet 15 tons per acre. The variety "Our Ideal" was the highest producing mangel, and the "Golden Tankard" the best yielding half-sugar beet.

The mangel produced about twice as much feed as the sugar beet but due to the high content of carbonaceous material in the sugar beet, it has a greater value per acre than the mangel. Also the sugar beets are in a more concentrated form and require much less labor in harvesting the crop. The beets from this test were


Sugar Beets Shortly After Thinning Showing an Almost Perfect Stand.

fed to the University Dairy herd, and a value was placed on the roots at the rate of $7.00 per ton for the sugar beets, $4.00 per ton for the half-sugar beets and $3.00 per ton for the mangels The sugar content varied from 4.5 per cent in the mangels to 19.5 per cent in the sugar beets.

These results indicate that the sugar beet is the most valuable root crop for feeding purposes under Nevada conditions. No silo is required for storing the beet. The method commonly used in Nevada where the rainfall is so slight, is to pit them in the ground in a similar manner to the pitting of potatoes. The beets are cut up by an ordinary feed cutter or chopper when fed to cattle or sheep. Stock feeders in Nevada have paid as high as $7.00 per ton for sugar beets to be used as a supplementary feed to alfalfa in preparing cattle and sheep for the market. The finely chopped beets are especially valuable in fattening ewes with poor teeth.

BEET TOP SILAGE.

In the Fallon district last year the sugar beet tops yielded as high as from two to five tons per acre. Many tons of these tops were used for silage this winter as a feed for cattle and sheep. Instead of being placed in a silo, the tops were pitted somewhat on the plan of pitting potatoes, the packing of the silage being done by the teams and wagons driving continuously over the long pile in unloading the silage. The piles were carefully covered and later fed to stock in connection with alfalfa hay.

In siloing tops it is necessary to follow the toppers and throw the beets tops in large piles to prevent them from drying. They should be hauled immediately to the pits for storage, and fed within the next few months. The beet top silage has about the same feeding value as the Russian thistle silage.

FILLING THE SILO.

Tests at the Experiment Station show that three-fourths of an inch is a very desirable length to cut the silage. This permits the silage to be well packed and the proper fermentation to take place. In filling the silo two or three men should continually

tramp over the silage in order that it is thoroughly packed. When possible an interval of a day between the periods of filling will greatly facilitate the packing.

Most of the silage crops grown in Nevada are too dry when cut to pack thoroughly. Water must therefore be added while the silo is being filled to make possible the necessary packing. Corn or other silage crops which have been partially dried by a killing frost before being cut will require the addition of considerable more water at the time of filling than would otherwise be necessary. The amount of water to add is determined by a man in the silo at the time of filling. Less injury will result in a slight excess than in a deficiency of water, although if too wet the silage is handled later with greater difficulty.

A common practice in covering the silage is to plant oats thickly on the top before the last wetting. The oat roots form a dense mass over the surface and exclude the air. The total cost of producing silage in Nevada will amount to three or four dollars per ton under existing conditions.

SILAGE AS A LIVESTOCK FEED.

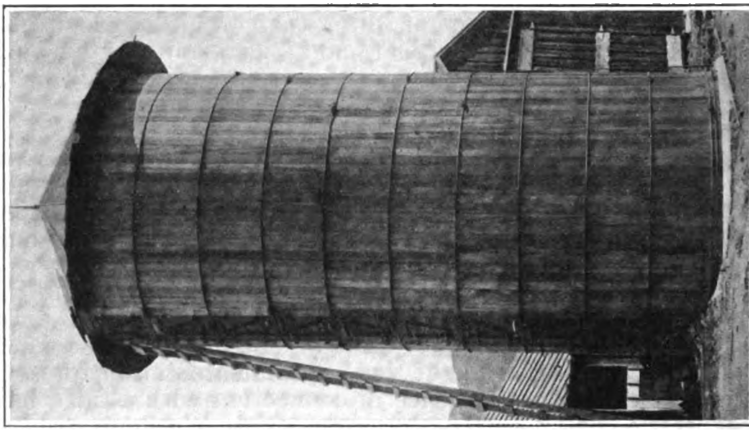
Corn silage has been fed at the Experiment Station for several years as a winter succulence in connection with alfalfa hay for beef cattle, dairy cattle and sheep with excellent results. Silage is one of the cheapest and most desirable winter feeds for dairy cows. Besides making a good balanced ration when fed in connection with alfalfa, it provides a succulent and palatable feed that largely counteracts the digestive troubles of cows fed on alfalfa alone. If given to the cows after milking the silage will not taint the milk. A good combination for dairy cows is about 30 pounds of silage and 15 pounds of alfalfa hay per head daily. If barley is added to the ration use about one pound of the grain for each four pounds of milk produced daily.

The Missouri Station found that with present prices of hay and grain, one of the cheapest and best combinations for fattening steers is corn silage, alfalfa hay and linseed oil meal or cotton seed meal. The South Dakota Station obtained more uniform and larger gains in fattening lambs by the addition of a small quantity of corn silage to the lambs' ration. The Iowa Station recommends the use of corn silage as a cheap and very profitable feed for wintering ewes. Silage is not recommended as a desirable feed for horses and hogs in Nevada. Care should be taken that no moldy or rotten silage is fed to any class of livestock.

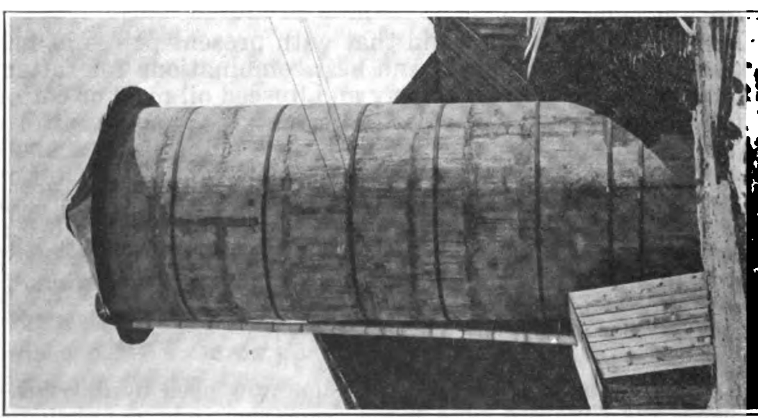
SILOS FOR NEVADA.

Of the various types of elevated silos now used by dairymen in the west the concrete type when properly constructed is the most durable and in the end the cheapest silo for Nevada. The concrete silos which have been used in Nevada for a number of years are giving excellent service and are showing no indication of wear.

The climatic conditions of Nevada, however, are very suitable for a long life with a good stave or redwood silo. The latter



A Redwood Stave Silo in the Truckee Valley.
Dimensions: 12x30 feet.



A Concrete Silo in the Truckee Valley.
Dimensions: 14x36 feet.

types are cheaper and can be built by the farmer with less difficulty and in a shorter time than the concrete silo.

THE PIT SILO.

At the present time the silo has found a place on a small percentage of the dairy farms of Nevada. One of the important reasons for this has been the cost of construction. This can be largely overcome by the use of an underground or "pit" silo, and in localities having limited rainfall this type will prove about as serviceable as the elevated variety, provided it is properly constructed. The pit silo can be built by the farmer himself at a cost which should not exceed $1.50 per ton capacity. It should be constructed in a clay soil where the ground water or water table is at least 25 feet below the surface.

The pit may vary in size, depending upon the number of animals to be fed, it usually ranges from 20 to 25 feet in depth and 10 to 15 feet in diameter. The depth should be about twice the width, and the walls should be kept perpendicular and circular in form. After about two feet of the soil has been removed a cement collar should be constructed to this depth, which serves as a protection to the surface opening. This collar should be about a foot wide at the bottom, and when thoroughly set the earth may be excavated to another four or five feet To prevent the silage juices from being absorbed by the soil it is necessary to cover the walls with cement. In a heavy clay where there is little danger of caving, a cover of one-half an inch of good rich cement mortar will be sufficient. The mortar should be made of one part cement to four parts of clean sand. Before this first coat of mortar is well set a second coat of this same mixture should be applied, and before the second coat gets well set, a third coat should be applied, using one part cement to three parts sand for this application. The walls should be troweled down smooth after this last coat and the excavation continued. By this method the plastering is finished at the bottom and a scaffold is not needed. With lighter clay soils it may be necessary to apply the mortar to a close-mesh rabbit wire or some similar material, which is firmly anchored to the dirt wall.

Even in such silos where the walls are not plastered, the silage keeps in good condition for the first year or two, but after this period all pit silos should be plastered. It is most desirable, however, to plaster the walls for the first year's crop. A floor is not required in the plastered or unplastered pit silo.

The chief objection to the pit silo is in the removing of the silage for use. Two simple methods may be employed for this purpose. The silage may be raised by hand by means of a swinging derrick in connection with a windlass and pulley; or, it may be raised by a horse in connection with a block and tackle.

This type of silo should be considered seriously by Nevada dairymen who are milking 20 or more cows, have a good market for their products, and are not prepared to build an elevated silo.

AMOUNT OF SILAGE REQUIRED.

The following table shows the approximate amount of silage required to feed 15 to 50 cows 180 and 240 days, based on a daily consumption of 40 pounds, or about one cubic foot of silage per head. *

Number of Dairy Cows	Feed for 180 Days	Feed for 240 Days	Diameter of Silo
15	54 tons	72 tons	10 feet
20	72 "	96 "	12 "
25	90 "	120 "	14 "
30	108 "	144 "	16 "
35	126 "	168 "	16 "
40	144 "	192 "	18 "
45	162 "	216 "	18 "
50	180 "	240 "	20 "

* Sheep require about one-sixth as much silage as dairy cows.

CAPACITY OF ROUND SILOS.

The following table shows the capacity in tons of round silos of different sizes:

CAPACITY IN TONS.

Inside Height of Silo	Inside Diameter in Feet. 10	12	14	16	18	20
14....	15					
18....	23	33	45			
22....	31	45	59			
26....	39	57	73	98	145	
30....	47	69	87	118	165	170
34....	55	81	101	138	189	220
38....	63	93	115	160	225	270
42....		105	129	190	250	310
46....			143	215	285	350
50....				245		382

Acreage to Fill, 15 Tons to the Acre.

	10	12	14	16	18	20
14....	1.0					
18....	1.5	2.2	3.0			
22....	2.0	3.0	3.9			
26....	2.6	3.8	4.8	6.5	9.7	
30....	3.1	4.6	5.8	7.9	11.0	11.3
34....	3.7	5.4	6.8	9.2	12.6	14.7
38....	4.2	6.2	7.7	10.7	15.0	18.0
42....		7.0	8.6	12.7	16.7	20.7
46....			9.5	14.3	19.0	23.4
50....				16.3		25.4

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

BULLETIN No. 92

IRRIGATION OF WHEAT IN NEVADA

BY

C. S. KNIGHT, B.S.

DEAN OF THE COLLEGE OF AGRICULTURE AND AGRONOMIST
OF AGRICULTURAL EXPERIMENT STATION

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. James F. Abel (1917-1921), Chairman........Reno
Hon. James W. O'Brien (1915-1919)........Sparks
Hon. John J. Sullivan (1915-1919)........Reno
Hon. B. F. Curler (1917-1921)........Elko
Hon. Edna C. Baker (1917-1919)........Sparks

OFFICERS

Walter E. Clark, Ph. D........President
Mrs. L. B. Blaney, B. A........Secretary
Charles H. Gorman........Comptroller

STAFF

Samuel B. Doten, M. A........Director and Entomologist
Charles S. Knight, B. S........Agronomist
Charles E. Fleming, B. S. A........Range Management
Edward Records, V. M. D........Veterinarian
James Edward Church, Jr., Ph. D........Meteorologist
C. Alfred Jacobson, Ph. D........Chemist
Stephen Lockett, V. M. D........Assistant Veterinarian
Harry W. Jakeman, V. M. D........Assistant Veterinarian
Maxwell Adams, Ph. D........Consulting Chemist
Peter Frandsen, A. M........Consulting Biologist
C. W. Lantz, A. M........Consulting Botanist and Horticulturist
Frederick W. Wilson, M. S........Consulting Animal Husbandman
Verner E. Scott, B. S........Consulting Dairy Husbandman
J. L. Webb........Bureau of Entomology, U. S. Department of Agriculture
Mrs. T. W. Cowgill, M. A........Librarian
Ruth Miller, B. A........Secretary to Veterinary Department
Hester Mayotte........Secretary to the Experiment Station

ACKNOWLEDGMENT

The writer is indebted to the following for pictures used in making cuts found in this bulletin:

F. B. Headley, Superintendent U. S. Experiment Farm, Fallon —Figs. 1, 10 and 12.

F. N. Cronholm, U. S. Reclamation Service, Fallon—Figs. 3, 4, 5, 6, 7 and 8.

F. L. Bixby, Irrigation Engineer—Figs. 11 and 13.

CONTENTS

Page

INTRODUCTION 5

METHODS OF IRRIGATING WHEAT IN NEVADA 5
Flooding from Field Ditches 5
Flooding in Borders 5
Flooding in Checks 6
Furrow Irrigation 7

USE OF THE TRACTOR IN PREPARING LAND FOR IRRIGATION 8
Tractor Operations on the Truckee-Carson Project 9
Laying Out the Land 10
Preparing Land for the Border Method of Irrigation 11
Location of Laterals and Sub-Laterals 12

AMOUNT OF WATER REQUIRED 13
Influence of Annual Rainfall 13
Total Precipitation and Distribution at the Nevada Station 13
Influence of Evaporation 14
Effect of Soil Mulches of Different Depths 15
Effect of Cultivation at Different Depths 15
Effect of Shallow and Deep Furrow Irrigation 15
Effect of Over-Irrigation on the Quality of Wheat 16

WHEN TO IRRIGATE THE WHEAT CROP 17
Results of Irrigation Investigations with Wheat 19
Best Results with 28 Inches of Water in Four Applications 19
Results with Three Applications 19
Yield per Acre-Foot of Water with Three and Four Irrigations and Seven-Inch Applications 20
Results with Two Irrigations 21
Yield per Acre-Foot of Water with Two Irrigations 21

RELATION OF SOIL MOISTURE TO TIME AND AMOUNT OF IRRIGATION 21
Comparing Soil Moisture Contents with One Irrigation Omitted 22
Comparing Soil Moisture Contents with Two Irrigations Omitted 23

IRRIGATION OF WHEAT IN NEVADA

INTRODUCTION

The approximate land area in the State of Nevada is 70,285,440 acres. Of this amount about 900,000 acres, or 1.3 per cent, were irrigated in 1917. The State abounds in rich agricultural land, but the lack of additional water for irrigation prevents the cultivation of regions which are now lying idle as waste desert areas. To increase the area of irrigated land it becomes necessary either to furnish additional water by means of artesian wells or pumping, or to make a more conservative use of the present water supply. The irrigation experiments at the Nevada station deal chiefly with the latter of these two methods. Many farmers in Nevada are continually applying too much water to their crops for the greatest yields per acre and the best quality of products. It is, therefore, very important to know the proper time of application and the amount of irrigation required for the best results with staple crops. Furthermore, in years of water shortage irrigations should be omitted at those stages of growth when the crop is least affected.

When water is pumped from a considerable depth for the irrigation of farm crops, the expense is very high as compared with the use of surface water. It, therefore, becomes important for the grower to use the least amount of water necessary for the greatest possible profit with the various crops.

During the past four years the Nevada Agricultural Experiment Station has conducted a series of investigations comparing the different methods of applying water to wheat to determine the amount of water required and the best time to apply water to the crop to obtain the best results; at which stage or stages of growth an application of water may be eliminated without greatly affecting the yield of grain, and also the most practical depths of applications where only two irrigations are possible. The average results of experiments on the irrigation of wheat are included in this bulletin.

METHODS OF IRRIGATING WHEAT IN NEVADA

FLOODING FROM FIELD DITCHES. This is the cheapest method to install and the most wasteful of water, also a great deal of labor is required in distributing the water over the field. It is sometimes called the contour method, since the field ditches carry the water along the ridges and distribute it down the slopes over the field.

FLOODING IN BORDERS. This is possible on comparatively level land. In preparing the field for this system the greatest care must be exercised in leveling the land accurately for the borders. A leveler commonly used in Nevada for this purpose is mounted on four wheels with a heavy iron blade which works something on the order of a road grader. Eight horses are generally

required to pull the leveler and two men for its operation, one driving and the other to operate the machine. On new land it is necessary to plow the ground before leveling, but on stubble land under cultivation the work can be done before the plowing is commenced. When the field is properly leveled with this implement, the borders are marked off on the head line from sixty to ninety feet wide. A huge V marker and ditcher is then used to make the levees which run at regular intervals, separating the borders. This is a heavy implement mounted on four wheels and controlled by a system of levers, and requires about twice as much power for its operation as the leveler. After these borders are seeded, a head ditch is then made with the same ditcher to carry the water to the borders. If one man is applying the water, he turns in as large a head as can properly be handled. Considerable experience is needed in this system of applying the water, because as soon as the soil at the upper ends of the borders

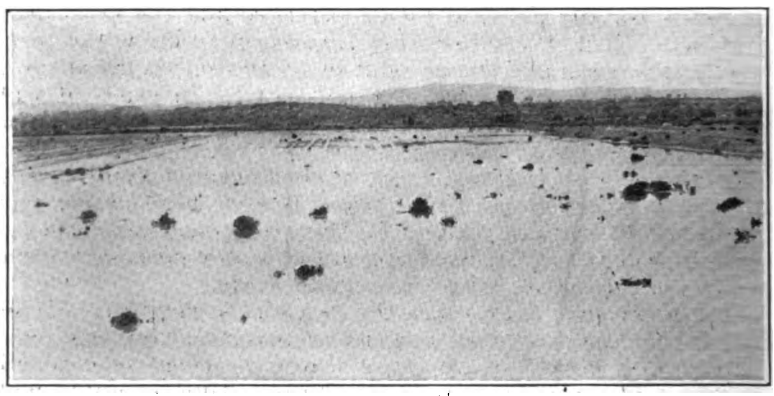


Fig. 1—Flooding new land on the Truckee-Carson Project

is sufficiently wet, the water must be taken down the ditches between the borders to irrigate the lower portions of the land. These borders vary from 1,000 to 5,000 feet in length, depending upon the slope of the land. With a properly installed system the water can be brought down one side of the field for a considerable distance in a diagonal direction, instead of bringing the water down the ditch and turning it into the borders at frequent intervals. In this way a large tract can be irrigated by one man in a day. In sections of Nevada where this system is practiced, wonderful crops of wheat are produced, but in such regions the soil is of a loose nature, contains large amounts of humus and does not bake after wetting. In this system one experienced irrigator can handle about six second feet of water.

FLOODING IN CHECKS. In this system of irrigation the levees are run across the field in both directions, dividing it into a series of basins. This method is largely practiced on new lands that require a great deal of leveling. The level tracts can be checked ready for the water without a great deal of expense. This system

is also desirable on lands that will not soak up well, when the water is run in the furrows. On the Truckee-Carson Irrigation Project, where this system is commonly used in the production of hay and grain, the levees dividing the checks or basins are wide and low and are generally covered with a crop. They are constructed to prevent any waste of land and to make possible the harvesting of the crop with the mower or binder. In such a system some checks are higher than others. Water is turned into the higher checks, and, when sufficiently wet, it is taken off and run into the lower checks, and so on until all the ground is irrigated. Although considerable water is lost by evaporation, very little goes into the drainage ditches. If land has a gentle slope, the installation of this system is very expensive, as compared with the border method and flooding from field ditches. A large head of water can be used with this system and one man can handle from seven to eight second feet.

Fig. 2—Furrow Method of Irrigation for Wheat

FURROW IRRIGATION. Where the conditions are suitable and the land is sufficiently friable and mellow, the furrow method of irrigation is best adapted to the highest returns in the production of grain in Nevada. In this system the water is run through the field in small furrows and diffuses laterally through the soil, but should not run over the surface. This system is adapted to small streams, considerable slopes and to heavy soils. The water may be run in a few or many furrows, it may be run across the slope at any angle for the desired flow of water and it gives the heavy soils time to soak up. The feed ditches are nearly level and are generally run across the slope of the field. In Nevada a great deal of trouble has been encountered in the washing away of the banks, when the water is taken from the distributing ditch to the furrows. This condition has been met by the use of galvanized iron pipes from one and one-half to two inches in diameter and two feet long. These iron pipes are placed in the bank

of the distributing ditch and each pipe furnishes water for from two to six furrows, depending upon the head of water in the feed ditch. By such a system a large field can be irrigated by one man, since his chief duty is to see that the proper head of water is maintained in the distributing ditches. Also, the water is more evenly distributed in the furrows, so that it reaches the lower part of the field in the different furrows at about the same time.

The length of furrows varies with the slope of the land and the nature of the soil from 200 to 800 feet, the greater lengths being possible in the heavy soils with the gentle slopes. Feed ditches are run across the field at these intervals of from 200 to 800 feet, and in turn furnish water for the irrigation of the check below. By making the furrows after the wheat is planted, no land is wasted. Although the initial expense is great in installing this system, the water is very easily handled and the expense of irrigating is small. With this system a much smaller head of water is used than with the other methods.

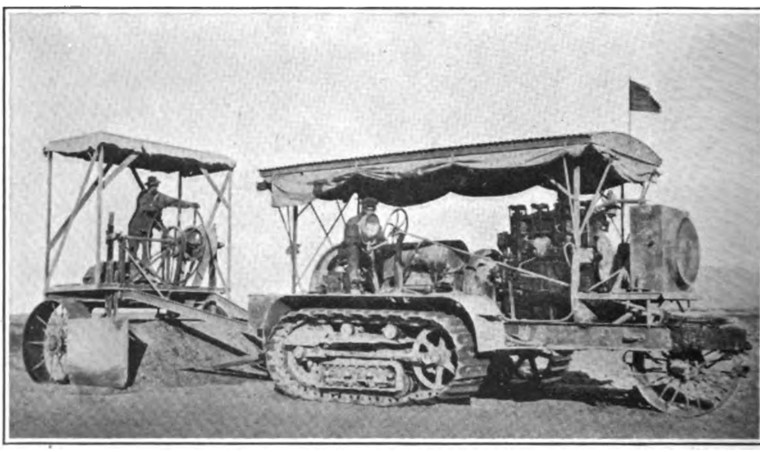


Fig. 3—Tractor and Land Leveler in Action

USE OF THE TRACTOR IN PREPARING LAND FOR IRRIGATION

Within the past ten years the tractor has become a very valuable machine where extensive farming is practiced in Nevada, and to some extent in the intensive farming districts. In such instances the tractor has replaced the horse labor in certain classes of farm work. On farms where both the tractor and horses are used to advantage the tractors have generally been used with economy. However, where the tractor is obtained as a novelty and is performing the field work while the horses are in the corral feeding on high-priced alfalfa hay the tractor is often used without profit.

The chief advantages in the use of the tractor are that it saves labor; can be used for extra heavy work for a continuous period;

may be operated for 24 hours a day if necessary; makes possible the preparation of ground at the proper time; and lessens the expense in preparing large areas for irrigation.

The tractor is being used extensively in preparing land for irrigation in the district of Wells in Elko County, the Battle Mountain district in Lander County, the Lovelock district in Humboldt County, Mason and Smith Valleys in Lyon County, the Truckee-Carson Project in Churchill County, in southern Washoe, and in Douglas County. In these districts the tractor is being used very successfully and has been an important factor in the reclamation and cultivation of large areas of waste land within the past few years.

TRACTOR OPERATIONS ON THE TRUCKEE-CARSON PROJECT

The United States Reclamation Service is now in the process of rough-leveling thirteen eighty-acre tracts, or 1,040 acres of land on the Truckee-Carson Project. This land will be opened for entry to homesteaders at the completion of this work.

Fig. 4—Moving Soil with the Tractor and Leveler

Such a system of preparing land for irrigation presents many advantages to the settler. Each of the eighty-acre units is leveled with the proper slopes and as a part of the entire area that is being leveled, thus making possible better irrigation and drainage systems for this land. The work is performed under the supervision of competent engineers, which involves a saving of time and money in the proper preparation of this land. The settler devotes his entire attention to the cropping of his homestead and is not required to deal with the perplexing problem of land leveling of which he knows little. The outlay in capital for the first few years is not so great, since the payments for leveling and for the water are distributed through a period of 20 years. Probably the most important feature of this plan is that the land is made very attractive to the settler, with the result that such

tracts will be filed upon shortly after they are opened to entry. The particular aim of the Government in this work is to increase food production and to stimulate the settlement of land on the project; also, if satisfactory arrangements can be made, to assist the settlers in increasing their present area of cultivated land.

The United States Reclamation Service, represented by F. N. Cronholm, Engineer, presented a paper on "Land Leveling With Tractors on the Truckee-Carson Project" at the Annual Farmers' Week, January 25th, 1918, in which he stated in part as follows:

LAYING OUT THE LAND

"In laying out the tracts for leveling it is necessary to make a careful study of the farm unit for proper water distribution, and a topography of the area. The main ditches, farm laterals and drains may then be located in conformity to the tract as a

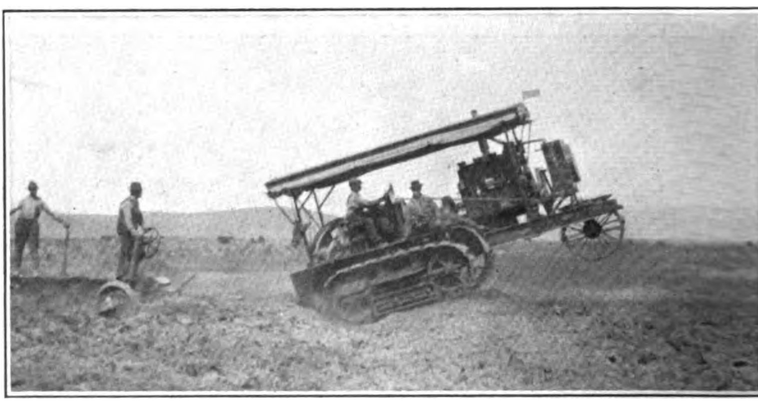


Fig. 5—Tractor and Plows passing through a big ditch

whole, and the direction of slope determined before the work of leveling is begun."

"On tracts where the general slope is hard to determine with the eye, contours every half foot in elevation should be taken. When the slope is quite pronounced intervals of one foot are ample and where the tract as a whole has a pronounced slope intervals every two feet are sufficient."

"After the topographic sheet has been prepared each farm unit is studied in the field and the plan of rough leveling outlined. As far as practicable the direction of irrigation is made to agree with the slope of the land; in fact, the slope of areas as small as five acres is considered in the scheme of irrigation and lay-out, and in most cases the plan permits subdivision of farm units down to twenty-acre units without materially affecting the scheme of water distribution, should this subdivision later be found divisible by the settler."

"In laying out a farm unit to be rough leveled it is important to keep in mind the prevailing slope as indicated on the topog-

raphy, possible water surface elevations and the ditch and drain scheme as contemplated. After all this has been roughly determined and the farm planned to agree with the general scheme of the entire tract, a line of elevations is taken around a five, ten or twenty-acre portion of the unit, depending on the general slope, if any. Stakes are then set at the lower and upper ends of the land as guides for the tractors doing the rough leveling. In beginning this work the lands are first plowed but not disked. The sod crumbles under the weight of the equipment, and as the shaping of the lands progresses the lumps disappear. The sandy lands are not plowed previous to the leveling."

"The lands are generally laid out in squares or rectangles with the view of requiring the least ditch length on each farm. The final leveling and shaping of the lands is done by the farmer at the time the levees and ditches are constructed. Work of this kind is generally done with the use of horses attached to Fresnos or tailboards."

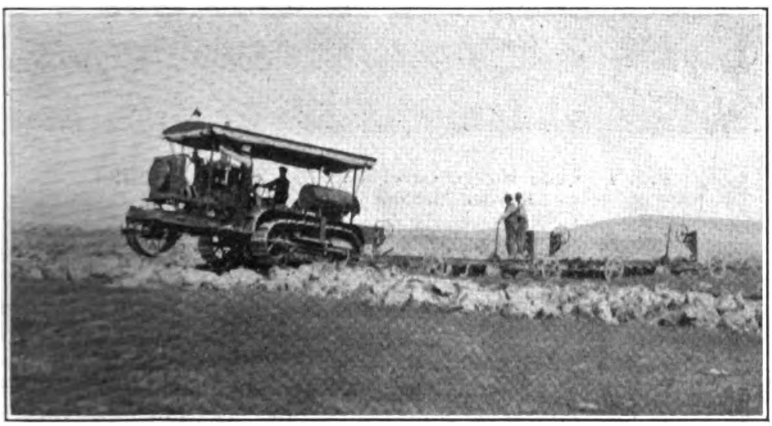


Fig. 6—Tractor and Plows passing over a high Levee

PREPARING LAND FOR THE BORDER METHOD OF IRRIGATION

"When the leveling is completed the land is divided into borders or strips by building low, wide parallel levees with the slope 60 to 70 feet apart. The slope of lands between levees, where soils are light, should not be less than 0.2 feet per hundred foot length. On heavier soils about 0.1 foot per hundred foot length is allowed as a minimum. The length of strips as they are being laid out by the Reclamation Service is from 330 to 660 feet, depending on topography, economic farm lateral layout and surplus irrigation water removal."

"Where the general slope is quite steep, up to three feet per hundred feet of length, depending on soils, it is possible, after a crop has been started, to use the 'border check' system of irrigation; however, to get a stand and avoid a waste of seed it is advisable after seeding to corrugate or furrow the lands between

levees and use this method of irrigation until a fair growth has been attained. Where soils are very porous and percolation is so great that water will not find its way through the length of furrow, the length of run can be cut in two by providing a temporary supply ditch. After the crop is up this ditch can be dispensed with and water supplied from the ditch at the head of the lands, and the furrows and strips flooded as is the general practice with the 'border check' method."

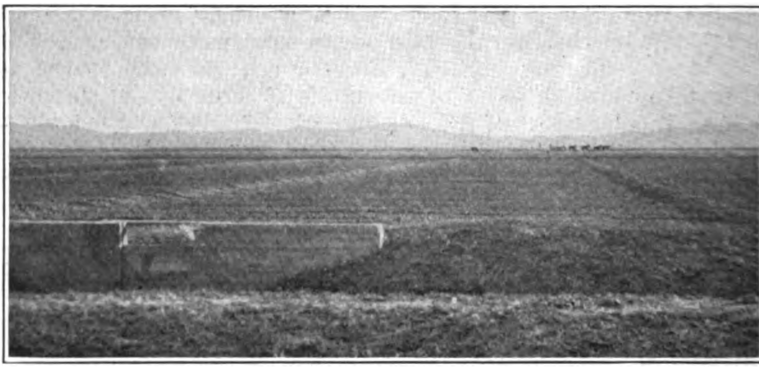


Fig. 7—Land Rough-Leveled by the Tractor for the Border Method of Flooding

LATERALS AND SUB-LATERALS

"When considering the sandy loam surface soils and the small amount of slope it is possible to give the lands on the tract now being worked, it is deemed advisable to provide twenty second feet of water as an irrigation head for each farm unit of eighty acres. Laterals should be made to handle this amount and sublaterals ten second feet. It is realized that the right amount of water for known surface and subsoils cannot adequately be predetermined, but it is thought that from five to ten second feet will be used in each check or strip composed of porous soils and possibly half of this amount on clay soils. Much of this is left to the farmer, and if he fails to maintain his laterals their capacity will be reduced. Small ditches are often the cause of under production and drainage difficulties, as they lead to the continuous flow system which is far more injurious and wasteful than a large irrigation head on the rotation basis."

"The settler will have much to do after the lands are rough leveled. He will have to build shelter for himself, provide stock, equipment, a well, and fences; do the final leveling, build ditches, levees, tail-water drains, irrigation boxes and structures, and plant trees around his property."

"Up to the present time two tractors have been used for this leveling, but it is planned to increase this number to five. Working 16 hours per day with five machines it is possible to rough-

level in the neighborhood of 300 acres of land each month. During the first eight months the two machines were operated for 16 hours most every working day and the amount of rough leveling averaged 126 acres per month."

"The cost of leveling the land will vary with the roughness and slope, the more level tracts costing less and the lands rougher in topography more, but a general average will amount to about $40.00 per acre."

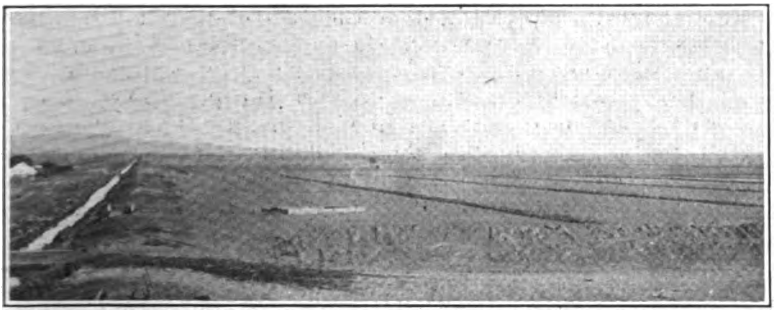


Fig. 8—This Land has received the Final Leveling and is Ready for Seeding

AMOUNT OF WATER REQUIRED

INFLUENCE OF ANNUAL RAINFALL. In many states where irrigation is practiced the annual precipitation is an important factor to be considered in the results of investigations on irrigation methods, and particularly in the duty of water in field practice. The following table gives the total precipitation and monthly distribution for the past four years and for a period of 28 years at the Experiment Station:

MONTHLY PRECIPITATION IN INCHES AT THE NEVADA AGRICULTURAL EXPERIMENT STATION
FOUR-YEAR PERIOD, 1914-17*

Month—	1914	1915	1916	1917	Aver.	Aver from 1889-1916
January	5.46	0.55	6.76	.05	3.20	2.02
February	0.86	2.59	0.59	2.01	1.51	1.20
March	trace	0.16	0.33	.74	.31	.83
April	0.70	0.33	0.11	.28	.35	.46
May	0.11	0.52	trace	1.18	.45	.73
June	0.29	0.00	0.11	.06	.11	.28
July	trace	0.04	trace	.04	.02	.36
August	0.38	trace	0.04	.12	.13	.31
September	0.05	0.06	0.35	trace	.11	.28
October	0.16	trace	1.13	trace	.32	.34
November	trace	0.28	0.05	.68	.25	.68
December	0.70	1.09	0.97	.27	.76	1.07
TOTAL	8.71	5.62	10.44	5.43	7.52	8.56

*Information secured from the U. S. Weather Bureau, Reno, Nevada.

It will be seen from the above table that the average annual precipitation for the four-year period of the irrigation investiga-

tions amounted to 7.52 inches. In the month of May, 1917, 1.18 inches of rain were received. With this exception, during no one month of the growing season throughout this period was sufficient rainfall received to affect the moisture content; that is, the small amount of precipitation at any one time was subject to evaporation within the few hours which followed. The results of these experiments are therefore based almost entirely on the water applied by irrigation.

The average precipitation over the entire state, according to the reports of the U. S. Weather Bureau, is about 8.5 inches per year. The only source of Nevada's water supply is the snow that falls upon her own mountain ranges and the precipitation upon the eastern slope of the Sierra in California. Throughout the agricultural districts of Nevada the rainfall is, in general, so slight and so poorly distributed during the growing season that it cannot be depended upon to supplement irrigation in supplying the moisture needs of crops.

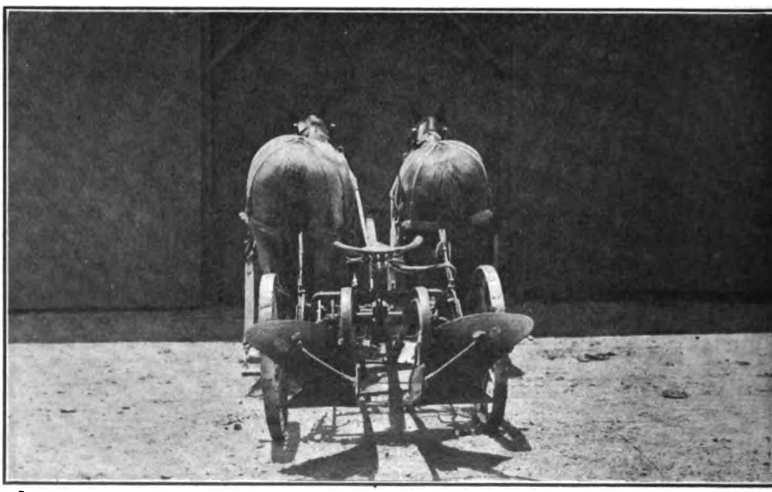


Fig. 9—The Two-Way Plow is an Excellent Tool in Preparing Wheat Land for Irrigation, since it leaves no Dead Furrow

INFLUENCE OF EVAPORATION. During the years 1908 and 1909 the Nevada Agricultural Experiment Station, in co-operation with the Office of Irrigation Investigations of the U. S. Department of Agriculture, conducted a series of experiments on the losses of water from irrigated soils by evaporation. These investigations were made at the Experiment Station farm near Reno at an altitude of 4,490 feet on a sandy, alluvial loam soil, which is typical of a large portion of the irrigated area in Nevada. The detailed results of these experiments are found in Bulletin 248, Office of Experiment Stations, U. S. Department of Agriculture. A summary of the results of this work follows.

EFFECT OF SOIL MULCHES OF DIFFERENT DEPTHS

Average evaporation from soils protected by different depths of soil mulches at the Nevada Agricultural Experiment Station for a period of three weeks (June 9-30 and Sept. 1-22, 1908) with six inches of water applied.

Depth of mulch—	Loss in inches	Loss in per cent of total application
Water surface	4.68	78.0
No mulch	1.41	23.6
3-inch mulch	.88	14.6
6-inch mulch	.36	6.0
9-inch mulch	.17	2.9

The unmulched surface shows a loss during the three weeks of 23.6 per cent of the six inches of water applied. The use of the 3-inch mulch shows a loss of 62.5 per cent, the 6-inch mulch a loss of 25.5 per cent and the 9-inch mulch a loss of 12 per cent, respectively, of the loss from the unmulched surface. These results indicate the value of a soil mulch when land is prepared for cropping and when possible during the growing season, especially with cultivated crops.

EFFECT OF CULTIVATION AT DIFFERENT DEPTHS

Average evaporation losses from cultivated and uncultivated surfaces at the Nevada Agricultural Experiment Station for a period of 28 days (May 7-June 4 and June 8-July 6, 1909) with six inches of water applied.

Cultivation—	Loss in inches	Loss in per cent of total application
Water surface	8.49	....
Cultivated six inches	1.09	18.2
Uncultivated	1.51	25.2

Duplicate tests were made in this experiment, and where cultivation was given the soil was stirred to a depth of six inches in a similar manner to natural field methods. The cultivated surface shows a loss of only 72.2 per cent, or a saving of 27.8 per cent of that receiving no cultivation, thus verifying the results previously mentioned in the value of cultivation to form a soil mulch in preventing the loss of water from the soil by evaporation.

EFFECT OF SHALLOW AND DEEP FURROW IRRIGATION

Average evaporation losses from surfaces irrigated by flooding, and with furrows of different depths at the Nevada Agricultural Experiment Station for a period of 28 days (July 8 to Aug. 5 and Aug. 10 to Sept. 7, 1909) with six inches of water applied.

Depth of furrow—	Loss in inches	Loss in per cent of total application
Water surface	11.13	....
Flooded	1.05	17.5
3-inch furrow	.91	15.2
6-inch furrow	.73	12.2
9-inch furrow	.55	9.2

The results of this experiment show that water run in furrows 3, 6 and 9 inches deep caused a saving of 13.3 per cent, 30.5 per cent and 47.6 per cent, respectively, of the total loss from the flooded surface during this period of 28 days. Where the supply

of water for irrigation is limited and the corrugation method of applying water is practical the use of furrows from 6 to 9 inches

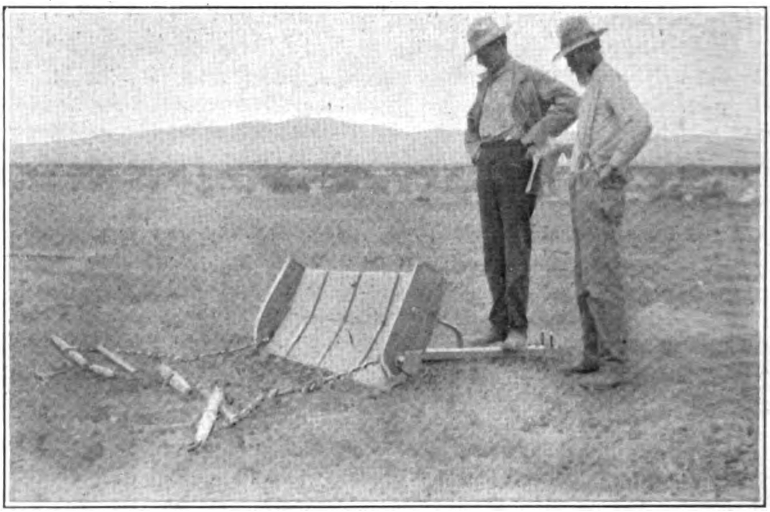


Fig. 10—A Tailboard Scraper, commonly used in preparing new land for irrigation

deep will undoubtedly result in greatly decreasing the loss of water from the soil by evaporation.

EFFECT OF OVER-IRRIGATION ON THE QUALITY OF WHEAT. An excessive use of water in the irrigation of the wheat crop seri-

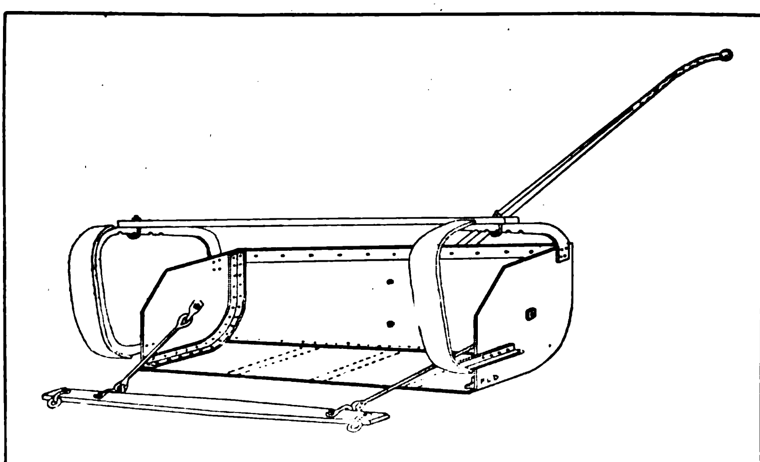


Fig. 11—A Fresno Scraper is an excellent tool in moving large quantities of soil a short distance, and for the final leveling

ously affects the quality of the grain for milling by producing soft, starchy kernels. On the well drained lands of Nevada, with

a conservative use of water, it is possible to produce the maximum yield of wheat of excellent quality for milling purposes. Such has been the experience of the Experiment Station even with the hard spring variety of Marquis wheat. However, where Marquis wheat has been grown on poorly drained land with a high water-table or on well-drained land where excessive irrigations were given, neither the yield nor quality of wheat were equal to the common White Club variety in these respects. Marquis wheat was grown at the Experiment Station for a period of five years with no decrease in the quality of wheat from year to year, when the crop received less than 30 inches of water with seven inches or less at each application.

WHEN TO IRRIGATE THE WHEAT CROP

The time to irrigate grain must be determined largely by the condition of the crop and the moisture content of the soil. Some irrigators determine this period by the color of the wheat, which turns dark green when in need of water. Others examine the

Fig. 12—A Fresno Scraper leveling land on the Truckee-Carson Project

first six inches of soil and learn by this method when the crop needs water. Still others contend that the crops should be irrigated at regular intervals, whether the crop needs it or not. A large number of farmers use the last method for determining the time to irrigate, and thus the crop generally receives a great deal more water than is required and the yield and quality of grain are often greatly affected by this practice. Unless the soil is very heavy in texture or varies greatly, the ground should be irrigated before planting. If heavy clay land is irrigated before seeding, sometimes several weeks are required for the soil to become dry enough to be worked and the weeds present are apt to be troublesome. When a field includes both light and heavy soils, a uniform stand of grain is quite impossible, and if irrigated when the

young plants are starting their growth above the ground, they are greatly checked in growth by the application of water at that time. Thus, such soils are generally irrigated after the grain is planted to germinate the seed. When irrigation is necessary immediately after planting, there is considerable danger of baking and crusting the soil, so that the ground will have to be irrigated again to soften the crust or cultivated with a corrugated roller or spike-tooth harrow with the teeth sloping well back to let the plants slip through.

The irrigation after germination should be withheld as long as possible to give the plants a chance to establish a good, vigorous root system in the soil to furnish the proper nourishment for the development of grain later on. However, the water should not be withheld until the lower leaves turn yellow. As a rule, the first irrigation after the grain has started is given between the time the five leaves are formed and the boot stage. If irrigated at the five-leaf stage, the second application is made at the boot stage, the third at the bloom, the fourth at the milk and the fifth

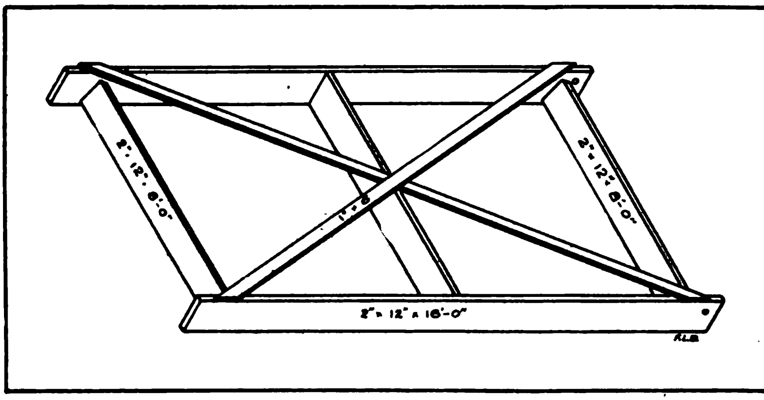


Fig. 13—A Home-Made Leveler is cheaply and easily made. It is commonly used on the irrigated farms of Nevada for leveling land for irrigation after plowing

at the dough stage. If the first irrigation is not required until the plants reach the boot stage or when the heads are forming, only four irrigations should be given. If only three irrigations are possible, the best results are recorded when applications are made at the boot, bloom and milk stages. However, this will vary with the nature of the soil, amount and distribution of annual precipitation, and the preparation of the seed bed. The proper time must be largely determined by the condition of the crop and the moisture content of the soil.

In many wheat sections of Nevada, heavy winds are common early every afternoon. In such localities the rank, growing grain which is approaching maturity should be irrigated at night or in the forenoon during the calm spell. This gives the culms, which soften near the surface of the ground, time to become firm before they are blown to the ground by the heavy wind. The last irrigation should never occur too late, especially in windy climates.

RESULTS OF IRRIGATION INVESTIGATIONS WITH WHEAT. In these experiments all wheat plats were irrigated at two or more of the five stages of growth, including the five-leaf, boot, bloom, milk and dough stages. The plats were about one-tenth acre in size, thus making possible the planting, irrigation and harvesting of the crop under normal field conditions.

BEST RESULTS WITH 28 INCHES OF WATER IN FOUR APPLICATIONS. The following table shows the average increase in yield per acre of wheat with 7-inch applications over 3-inch applications for the four-year period, 1914-17.

AVERAGE YIELD PER ACRE IN BUSHELS

One irrigation omitted at	3-inch application	7-inch application	Aver. per cent increase
Five-leaf stage	30.0	34.1	13.7
Boot stage	22.6	26.9	13.6
Bloom stage	21.2	28.0	32.1
Milk stage	27.5	30.1	9.5
Dough stage	27.5	31.2	13.4

In this experiment the best results were obtained with 28 inches of water in four applications, omitting the irrigation at the five-leaf stage. The average results shown above are strongly in favor of the 7-inch applications. Very little difference is noted in yield of wheat when irrigations were omitted at the milk and dough stages, respectively. The lowest yields with both 3-inch and 7-inch applications are found with irrigations omitted at the boot and bloom stages, respectively.

When 7-inch applications were given at each stage of growth, or a total of 35 inches of water, the yield was 32.8 bushels per acre, or about 4 per cent less than where only 28 inches of water were applied and the irrigation omitted at the five-leaf stage. This may be attributed to the greater development of root system, with the first irrigation omitted, and at the same time the plants did not suffer from lack of sufficient moisture before the irrigation at the boot stage.

RESULTS WITH THREE APPLICATIONS. The following table shows the average increase in yield per acre of wheat with 7-inch applications over 3-inch applications for the four-year period, 1914-17.

AVERAGE YIELD IN BUSHELS PER ACRE

Two irrigations omitted at	3-inch application	7-inch application	Aver. per cent increase
Five-leaf and boot	17.6	20.7	17.6
Five-leaf and bloom	21.6	23.6	9.3
Five-leaf and milk	28.3	30.0	6.0
Five-leaf and dough	27.5	32.4	17.8
Boot and bloom	12.5	19.7	57.6
Boot and milk	21.9	23.8	8.7
Bloom and milk	22.3	22.6	1.3
Bloom and dough	23.7	28.6	20.6
Milk and dough	28.4	30.5	7.4
No irrigations omitted	30.0	32.8	9.3

The results shown in this table are also in favor of the 7-inch applications, although the variations in yield are much more pronounced. The highest yield of 32.4 bushels per acre was obtained with 21 inches of water in three irrigations with applications omitted at the five-leaf and dough stages. The three lowest yields with 7-inch applications, averaging 21 bushels per acre, were obtained with irrigations omitted at the five-leaf and boot, bloom and milk, and boot and bloom stages, the last yield being 19.7 bushels per acre.

The low yields with both 3-inch and 7-inch applications when irrigations were omitted at the boot and bloom stages, indicate that the most critical period in the irrigation of wheat is between the boot and milk stages. When irrigations were omitted at the five-leaf and milk, and five-leaf and dough stages, very little difference was found in the yield, the average being 30.3 bushels per acre with 21 inches of water in three applications.

YIELD PER ACRE-FOOT OF WATER WITH THREE AND FOUR IRRIGATIONS AND 7-INCH APPLICATIONS. The following table shows a comparison between the yield per acre and yield per acre-foot of water with three and four irrigations and 7-inch applications for the four-year period, 1914-17.

AVERAGE YIELD IN BUSHELS FOR THE FOUR-YEAR PERIOD, 1914-17

One irrigation omitted at	Total irrigation inches	Yield per acre	Yield per acre foot of water
Five-leaf stage	28	34.1	14.8
Boot stage	28	26.9	11.5
Bloom stage	28	28.0	12.0
Milk stage	28	30.1	12.9
Dough stage	28	31.2	13.4
Two irrigations omitted at			
Five-leaf and boot	21	20.7	11.8
Five-leaf and bloom	21	23.6	13.5
Five-leaf and milk	21	30.0	17.1
Five-leaf and dough	21	32.4	18.5
Boot and bloom	21	19.7	11.3
Boot and milk	21	23.8	13.6
Bloom and milk	21	22.6	12.9
Bloom and dough	21	28.6	16.3
Milk and dough	21	30.5	17.4
No irrigations omitted	35	32.8	11.2

It is interesting to note that where a total irrigation of 28 inches of water was given in four applications the highest yield per acre is accompanied by the highest yield per acre-foot of water, which shows conclusively that this is the most practical method presented for the irrigation of the wheat crop.

The highest yield per acre-foot of water was produced with 21 inches of water in three applications, and where irrigations were omitted at the five-leaf and dough stages. The lowest yield per acre-foot of water was obtained with 35 inches of water in five 7-inch applications.

RESULTS WITH TWO IRRIGATIONS. The following table compares the yield of wheat per acre and yield per acre-foot of water where only two irrigations are possible and different depths of application are used before and after heading:

AVERAGE YIELD IN BUSHELS FOR THE FOUR-YEAR PERIOD, 1914-17

Irrigation inches before heading	Irrigation inches after heading	Yield per acre	Yield per acre—foot of water
6	6	26.8	26.8
6	9	24.1	19.6
6	12	27.0	18.0
9	6	24.0	19.3
9	9	31.0	20.7
9	12	27.7	15.8
12	6	27.0	17.7
12	9	27.0	15.6
12	12	28.2	14.1

Where only two irrigations are possible the two 9-inch applications, one before and one after heading, gave the greatest yield of 31 bushels per acre, or 10 per cent less than the highest yield with 28 inches of water in four applications. The 12-inch irrigation before heading apparently provided more water than the crop utilized to the best advantage. The maximum yield with two irrigations was obtained with a total of 18 inches of water applied when the crop turned dark green in color. With a total irrigation of less than 18 inches the yield was considerably decreased; whereas a total irrigation of 24 inches in two 12-inch applications produced an average of 28.2 bushels per acre of about 10 per cent less than where the two 9-inch applications were used.

YIELD PER ACRE-FOOT OF WATER WITH TWO IRRIGATIONS. The highest yield of 27.4 bushels per acre-foot of water was obtained with the smallest total irrigation of 12 inches, and the lowest yield of 14.1 bushels with the largest total irrigation of 24 inches. The second highest yield of 20.7 bushels per acre-foot of water was produced with the two 9-inch applications, which indicates that this is the most practical method presented to irrigate wheat when only two applications are given.

With only two irrigations the yields were generally lower throughout than with a greater number of applications using the same total amount of water. It is therefore recommended that only in cases of water shortage is it advisable to use only two irrigations in preference to three or four applications, as shown in the results of these experiments where the yields of grain are generally much higher. It should be noted, however, that with only two irrigations possible, a profitable crop of wheat can be grown.

RELATION OF SOIL MOISTURE CONTENT TO TIME AND AMOUNT OF IRRIGATIONS

In conducting this experiment on the irrigation of wheat soil samples were taken at regular intervals each year during the period of irrigation to determine the variation in moisture con-

tent in relation to the time of irrigation and the depth of application.

COMPARING SOIL MOISTURE CONTENTS WITH ONE IRRIGATION OMITTED. The following table shows a comparison of the soil moisture contents before the first irrigation and at harvest with three-inch and seven-inch applications, and with one irrigation omitted.

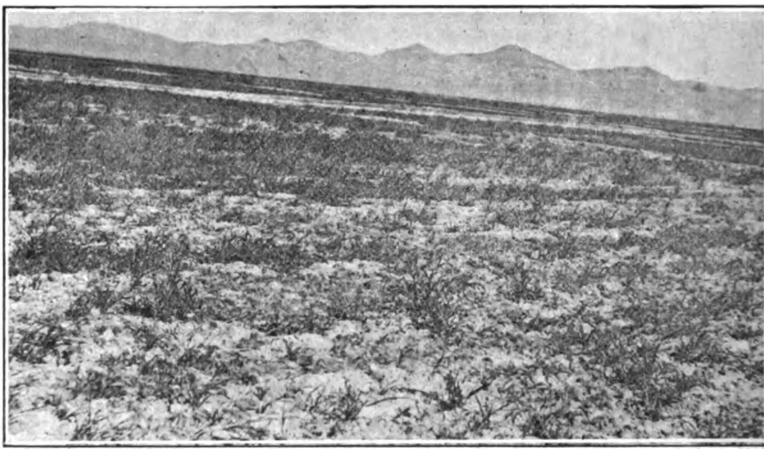


Fig. 14—Over-irrigation brings an excess of alkali to the surface. Note the thin stand of wheat on this land

AVERAGE DECREASE AT HARVEST IN PERCENTAGE FOR THE FOUR-YEAR PERIOD, 1914-17

Irrigation omitted	3-inch application	Yield bu. per acre	7-inch application	Yield bu. per acre
None	12.3	30.0	7.3	32.8
Five-leaf	23.5	30.0	.5*	34.1
Boot stage	20.7	22.6	2.4*	26.9
Bloom stage	.5	21.2	10.9*	28.0
Milk stage	9.0	27.5	2.7*	30.1
Dough stage	36.2	27.5	16.8	31.2

*Average increase.

The results herein presented show that the high yields per acre are generally accompanied with the greatest decrease in soil moisture content at harvest as compared with the soil moisture content before the first irrigation. With the 3-inch applications the smallest decrease in soil moisture content at harvest, with an irrigation omitted at the bloom stage, was accompanied by the lowest yield of 21.2 bushels per acre, or 60 per cent less than the highest yield with one irrigation omitted at the five-leaf stage.

With 7-inch applications the greatest increase in soil moisture content at harvest was obtained when an irrigation was omitted at the bloom stage, and the yield was 28 bushels per acre, or 21.8 per cent less than the highest yield.

These results show that the omission of an irrigation at the bloom stage seriously checks the development of the wheat crop

and prevents the plants from utilizing the moisture in the soil to the best advantage during the later periods of growth.

COMPARING SOIL MOISTURE CONTENTS WITH TWO IRRIGATIONS OMITTED. The following table shows a comparison of soil moisture contents before the first irrigation and at harvest with 3-inch and 7-inch applications, and with two irrigations omitted.

AVERAGE DECREASE AT HARVEST IN PERCENTAGE FOR THE FOUR-YEAR PERIOD, 1914-17

Irrigation omitted	3-inch application	Yield bu. per acre	7-inch application	Yield bu. per acre
Five-leaf and boot	15.2	17.6	2.5	20.7
Five-leaf and bloom	2.1	21.6	11.2*	23.6
Five-leaf and milk	21.1	28.3	5.1	30.0
Five-leaf and dough	10.4	27.5	4.9	32.4
Boot and bloom	1.5	12.5	0.0	19.7
Boot and milk	10.5	21.9	7.9	23.8
Bloom and milk	17.9	22.3	6.8*	22.6
Bloom and dough	24.4	23.7	0	28.6
Milk and dough	33.1	28.4	13.2	30.5

*Average increase.

It is noted in these results that with the 3-inch applications the smallest decrease in soil moisture content at harvest is found with two irrigations omitted at the boot and bloom stages, and accompanied by the lowest yield of 12.5 bushels per acre. The next lowest decrease in soil moisture content at harvest is with irrigations omitted at the five-leaf and bloom stages, accompanied by a comparatively low yield of 21.6 bushels per acre.

With the 7-inch applications it is interesting to note that where no decrease or where an increase is shown in the soil moisture content at harvest, one of the irrigations omitted in each instance was at the bloom stage. The average yield of these four plats was 23.6 bushels per acre, or 37.2 per cent less than the highest yield with one irrigation omitted at the five-leaf stage. This tends to confirm the previous statement that an irrigation omitted between the boot and milk stages may seriously check the proper development of the crop.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

BULLETIN No. 93—APRIL, 1918

Irrigation of Alfalfa in Nevada

BY

C. S. KNIGHT, B. S.

DEAN OF THE COLLEGE OF AGRICULTURE AND AGRONOMSIT
OF THE AGRICULTURAL EXPERIMENT STATION

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. James F. Abel (1917-1921), Chairman......Reno
Hon. James W. O'Brien (1915-1919),......Sparks
Hon. John J. Sullivan (1915-1919)......Reno
Hon. B. F. Curler (1917-1921)......Elko
Hon. Edna C. Baker (1917-1919)......Sparks

OFFICERS

Walter E. Clark, Ph. D......President
Mrs. L. B. Blaney, B. A......Secretary
Charles H. Gorman......Comptroller

STAFF

Samuel B. Doten, M. A.,......Director and Entomologist
Charles S. Knight, B. S......Agronomist
George Hardman, M. S......Assistant Agronomist
Charles E. Fleming, B. S. A......Range Management
N. F. Peterson, B. A., M. A......Assistant in Range Management
Edward Records, V. M. D......Veterinarian
James Edward Church, Jr., Ph. D......Meteorologist
C. A. Jacobson, Ph. D......Chemist
Stephen Locket, V. M. D......Assistant Veterinarian
Harry W. Jakeman, V. M. D......Assistant Veterinarian
Maxwell Adams, Ph. D......Consulting Chemist
Peter Frandsen, A. M......Consulting Biologist
C. W. Lantz, A. M......Consulting Botanist and Horticulturist
Frederick W. Wilson, M. S......Consulting Animal Husbandman
Verner E. Scott, B. S......Consulting Dairy Husbandman
J. L. Webb......Bureau of Entomology, U. S. Department of Agriculture
Ruth Miller, B. A......Secretary to Veterinary Department
Mrs. T. W. Cowgill, M. A......Librarian
Hester Mayotte......Secretary to the Experiment Station

TABLE OF CONTENTS

	Page
INTRODUCTION	5
NEVADA WATER SUPPLY AND DRAINAGE AREAS	5
Humboldt River	6
Truckee River	6
Carson River	6
Walker River	6
Muddy River	6
Small Streams in Northern Nevada	6
Artesian Wells in the Las Vegas Valley	6
Washoe Lake	6
IRRIGATED AREA IN NEVADA	7
METHODS OF IRRIGATING ALFALFA IN NEVADA	7
AMOUNT OF WATER REQUIRED FOR ALFALFA IN NEVADA	8
Type of Soil	8
Lay of the Land	9
Hardpan Near the Surface	9
Effect of Evaporation on the Amount of Water Required	10
Duty of Water on Alfalfa at tho Experiment Station, 1906-11	10
Duty of Water on Alfalfa Under Field Conditions in the Carson Valley, 1907	12
IRRIGATION INVESTIGATIONS WITH ALFALFA, 1915-17	13
WHEN TO IRRIGATE ALFALFA	13
AMOUNT OF WATER APPLIED	15
Relation of Soil Moisture Content to Time and Amount of Irrigation	16

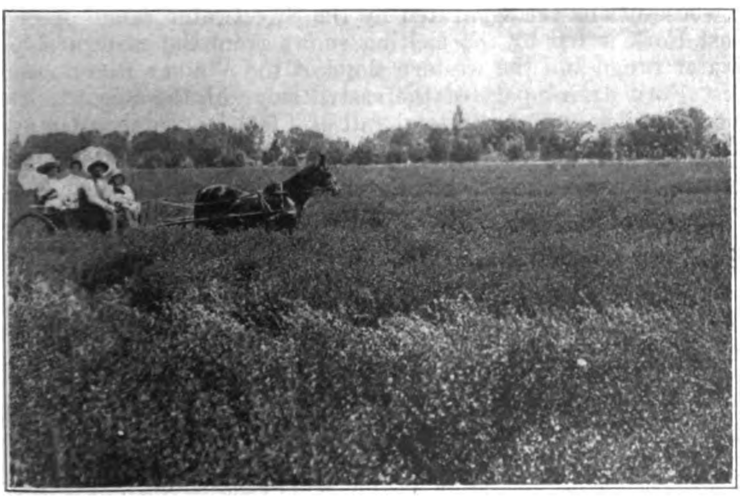
Irrigation of Alfalfa in Nevada

INTRODUCTION

Alfalfa is the chief cultivated crop grown in Nevada. In the course of the last eight years the acreage of alfalfa in this State increased from 89,000 to about 135,000 acres, or over 50 per cent; the yield from 235,000 to about 472,000 tons, or an increase in production of more than 100 per cent.

Practically all of the alfalfa in Nevada is grown under irrigation. The irrigated lands furnish a natural home for this crop, but nevertheless there is considerable question as to the best methods of irrigation and the amount of water required for alfalfa under existing conditions.

A large part of the acreage of alfalfa in Nevada receives too much water for the greatest yields and best quality of hay, and for maintaining high producing soils. Our irrigation investigations with alfalfa, the results of which are contained in this bulletin, were conducted for the purpose of determining the effect of different methods of irrigation on alfalfa. They show that by a more conservative use of water the acreage of this crop may be increased with the present water supply, and at the same time the land may be kept in a higher state of fertility.



Nevada furnishes an ideal home for alfalfa.

NEVADA WATER SUPPLY AND DRAINAGE AREAS

Nevada lies almost wholly within the Great Basin. In fact, with the exception of small streams tributary to the Snake River in the northeastern corner of Nevada and some branches of the Colorado River in the southeastern corner, the rivers drain into the interior of the State. These rivers are fed from the snowfall on the mountains of Nevada and the eastern

slope of the Sierra in California. The Humboldt, Truckee, Carson, Walker and Muddy are the principal rivers used for irrigation.

HUMBOLDT RIVER. This river has a length of 350 miles by air line, but measured in its irregular course it covers a distance of about 1000 miles. The melting snows of the Ruby, East Humboldt, Independence and Diamond ranges are the sources of this river; it drains into the Humboldt Sink at the lower end of the Lovelock Valley. This stream has a drainage basin of 13,800 square miles, all within Nevada. More than 50 per cent of the irrigated area in this State receives its water from the Humboldt.

TRUCKEE RIVER. This is the most northerly river on the eastern slope of the Sierra emptying into the Great Basin. It receives its water supply chiefly from mountain lakes which are fed by the melting snow of the Sierra in California. It is the outlet of Lake Tahoe, which has an elevation of 6,225 feet and covers an area of 193 square miles. The course of the Truckee is about 110 miles long, in which distance it has a total fall of 2,350 feet. It has a drainage basin of 2,310 square miles.

CARSON RIVER. This river is formed by the East and West Forks, which receive their water supply from the melting snow of the eastern slopes of the Sierra Nevada in California. The river is about 120 miles long and has a total fall of 1900 feet. It has a drainage basin in Nevada of 988 square miles.

WALKER RIVER. This is the most southerly river draining from the Sierra Nevada into the Great Basin. It is formed by the East and West Forks, whose basins are separated by the Sweetwater range of mountains. The East Fork is fed by the melting snows from the eastern slope of the Sweetwater range and the western slope of the Walker River range, while the West Fork drains part of the eastrn slope of the Sierra. This river is about 120 miles long, has a total fall of 1,600 feet, and a drainage basin of 2,420 square miles.

MUDDY RIVER. The Muddy River is located in the southeastern part of Nevada. It receives its supply of water from constantly flowing springs in Arrow Canyon, and drains into the Colorado River. It has been estimated that the average annual flow of this river is about 28,000 acre-feet of water.

SMALL STREAMS IN NORTHERN NEVADA. The small streams in northern Nevada furnish water for about 14 per cent of the total irrigated area. The principal streams are the White River, Duck Creek, Steptoe Creek, Salmon River, Bruneau River and Owyhee River. The White River is 75 miles long and has an average annual flow of about 28,000 acre-feet. Duck Creek and Steptoe Creek supply Steptoe Valley, and the Salmon, Burneau and Owyhee irrigate a considerable area in Nevada before emptying into the Snake River basin.

ARTESIAN WELLS IN THE LAS VEGAS VALLEY. In this valley about 50 artesian wells which develop flows at from 200 to 400 feet depths furnish the water supply for the irrigation of a considerable area.

WASHOE LAKE. By means of large pumping plants several thousand acres of land have been under intensive cultivation with the water from Washoe Lake. The water is elevated from 40 to 125 feet by the different plants.

IRRIGATED AREA IN NEVADA

The following table taken from the twelfth and thirteenth census shows the total irrigated area in Nevada for 1900 and 1910, with the increase in per cent for the ten-year period:

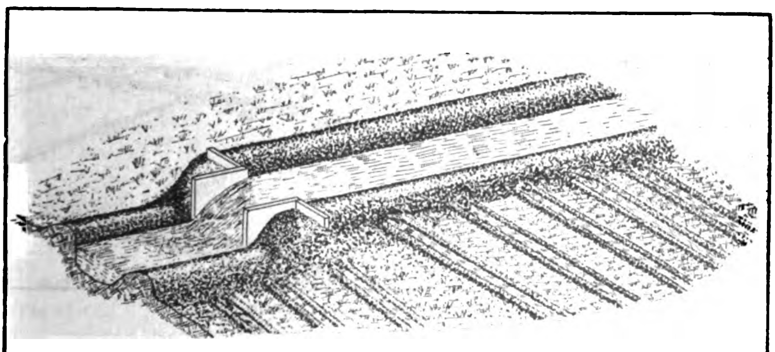
IRRIGATED AREA BY COUNTIES IN NEVADA, ACREAGE

County.	1900	1910	Per Cent Increase 1910
The State	504,168	701,833	39.2
Churchill	29,533	35,114	18.9
Clark	(a)	8,116	....
Douglas	25,861	32,181	24.4
Elko	156,446	183,552	17.3
Esmeralda (b)	6,181	14,011	126.7
Eureka	21,831	18,715	14.3
Humboldt	124,959	207,753	66.3
Lander	18,803	23,342	24.1
Lincoln (a)	9,962	9,907	(a)
Lyon	32,422	62,148	91.7
Nye	12,666	19,978	57.7
Ormsby	1,563	2,426	55.2
Storey	690	891	29.1
Washoe	43,855	50,904	16.0
White Pine	19,366	32,795	69.3

(a) Change in boundary. Lincoln County divided into Lincoln and Clark Counties.

(b) Change in boundary. Esmeralda County divided into Esmeralda and Mineral Counties.

It is noted from this table that about 30 per cent of the total irrigated area is located in Humboldt County and 56 per cent in Humboldt and Elko Counties, this area being irrigated from the Humboldt River and its tributaries.



Furrow irrigation by means of pipes.

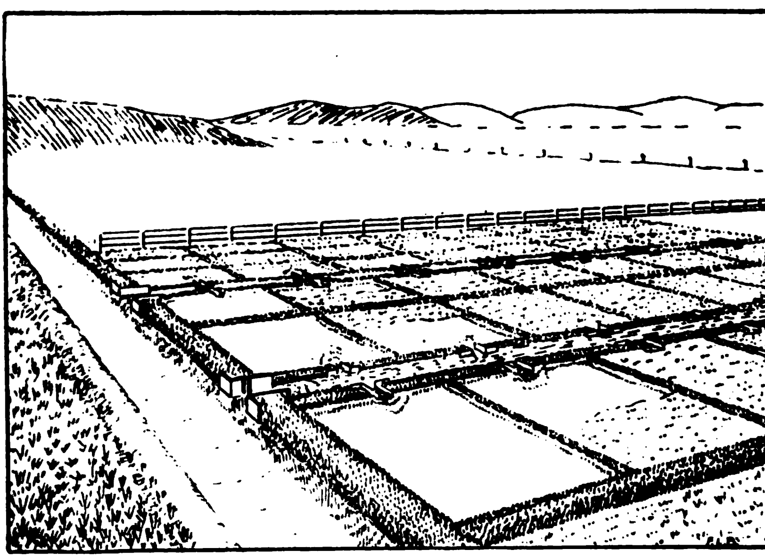
METHODS OF IRRIGATING ALFALFA IN NEVADA

The greater portion of the alfalfa acreage in Nevada is irrigated by some form of flooding. In the Lovelock Valley the border method of flood-

ing is generally used; on the Truckee-Carson Project the check system of flooding; in Washoe Valley, flooding from field laterals and by the furrow method, and in the Carson Valley the furrow or corrugation method is most common.

On the heavy soils in the Truckee Valley practically every field is furrowed, but the land is usually flooded from field laterals. The object of the furrows is to provide an easy channel for the water to the lower end of the field and after completing each irrigation to provide a run-off for any water which might otherwise remain standing in the low places, thereby retarding the growth of plants.

In the irrigation of alfalfa on light, sandy soils it is very important to have available a sufficient head of water to flood the field in a short time so that very little water will be wasted by percolation through the soil beyond the depth of the plant roots. With the heavy clay loam or clay soils a relatively small head of water is required for a longer period of time, since the water percolates less rapidly through these soils. The heavy soils, however, have greater power for retaining water, and are better suited to fewer and heavier irrigations. Frequent, light applications of water generally result in the best crops on the sandy and sandy-loam soils. Each method of irrigation is generally peculiarly adapted to the soil conditions and lay of the land in the district wherein it is practiced. For detailed information on the different methods of irrigation see Nevada Experiment Station Bulletin No. 91 on "THE IRRIGATION OF WHEAT IN NEVADA."



Check method of irrigation.

AMOUNT OF WATER REQUIRED FOR ALFALFA IN NEVADA

The amount of water required for alfalfa in Nevada varies with a number of conditions, chief among which are the type of soil, the lay of the land, a hardpan near the surface and the annual evaporation.

TYPE OF SOIL. The type of soil probably causes greater variation in

the amount of water required than any other one factor. In 1906, 12½ acres of alfalfa at the Experiment Station growing on gravelly soil with a very open gravelly subsoil received a total depth of 8.5 feet of water and produced only two tons per acre. The yield per acre-foot of water was only .24 tons per acre. During the same year two acres of alfalfa growing on a sandy clay soil with a clay subsoil received a total depth of 3 feet of water and produced 7.36 tons per acre or a yield of 2.45 tons per acre-foot of water.

LAY OF THE LAND. On lands that are rolling or that have steep slopes the amount of run-off is large, thus increasing the total irrigation required to produce the best crops. On the more uniformly level lands with light slopes practically all of the water applied may be retained by the land that is irrigated. On certain alfalfa fields in the Truckee Meadows where the land is rolling the total annual depth of irrigation varies from 10 to 15 feet, but more than two-thirds of this amount is run-off that is used again on lower lands or drains back into the Truckee River.

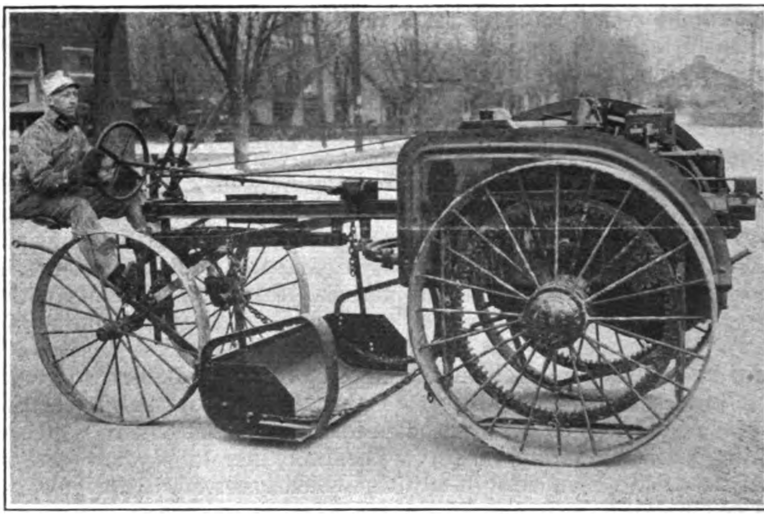
HARDPAN NEAR THE SURFACE. The following table shows the results obtained in 1910 on an acre of alfalfa which received 12 irrigations with a total of about six acre-feet of water:

EFFECT OF HARDPAN ON THE AMOUNT OF WATER REQUIRED FOR ALFALFA *

Date of Irrigation 1910			Depth of Irrigation.. Feet.	YIELD IN TONS First Cutting	Second Cutting	Third Cutting	Total
April	19	.126					
April	20	.239					
May	5	.408					
May	23	.646					
June	3	.662					
			2.081	1.65			
June	16	.759					
June	27	.537					
July	7	.225					
July	8	.436					
			1.957		1.55		
July	29	.523					
August	6	.676					
August	12	.661					
			1.860			1.77	
Sept.	14	.390	Irrigation for pasture				4.97
Total Irrigation			6.288				

* A heavy clay soil with a hardpan layer very close to the surface.

It is noted from these results that soils with a hardpan near the surface have very little capacity for receiving and retaining water, and in this instance about twice as much water was required to produce a crop as was necessary on similar soils without a hardpan layer near the surface.



A Fresno Scraper attached to a Moline Tractor; used in leveling land for irrigation.

EFFECT OF EVAPORATION ON THE AMOUNT OF WATER REQUIRED. The following table shows the average evaporation by months at the Experiment Station from still water surfaces for the year 1912:

EVAPORATION FROM WATER SURFACES AT THE EXPERIMENT STATION IN 1912

Month	Evaporation Feet
January	.101
February	.143
March	.110
April	.289
May	.569
June	.867
July	.950
August	.951
September	.608
October	.452
November	.182
December	.134
TOTAL	5.356

The annual evaporation from water surfaces at the Experiment Station is shown to exceed five feet the greatest loss occurring during the months of June, July and August. At the Experiment Station on cultivated land the average loss of water annually by evaporation amounts to about fifteen inches.

It is quite evident from these results that where the annual evaporation is high, more water is required to produce a crop than in districts where the normal conditions of evaporation prevail.

DUTY OF WATER ON ALFALFA AT THE EXPERIMENT STATION, 1906-11. The following table shows the average results in total irrigation, yield per

acre and yield per acre-foot of water at the Experiment Station for the six-year period, 1906-11:

DUTY OF WATER ON ALFALFA AT THE EXPERIMENT STATION 1906-11.

Year	Plat	Size of Plat Acres	Total Water Applied ft.		Yield per Acre. Tons		Yield per Acre Foot of Water. Tons	
1906		2	3.0		7.36		2.45	
Average				3.0		7.36		2.45
1907	20	1	5.42		5.63		1.03	
	21	1	5.42		5.04		.92	
	22	1	4.61		5.11		1.10	
	23	1	4.61		5.92		1.28	
	24 & 25	2	5.87		7.04		1.19	
Average				5.18		5.75		7.38
1908		1	4.32		7.12		1.54	
		1	3.30		6.02		1.69	
		1	2.47		6.04		2.20	
		1	2.92		5.66		1.46	
		2	4.76		5.13		1.02	
Average				3.55		5.99		1.58
1909	15	1	2.22		4.35		1.95	
	16	1	3.48		4.23		1.21	
	24	1	5.28		6.57		1.22	
	25	1	2.98		6.21		2.09	
	26, 27, 28	3	3.57		4.15		1.16	
	20	1	2.54		6.94		2.73	
	21	1	2.33		6.50		2.78	
	22	1	3.76		4.60		1.22	
	23	1	2.21		6.22		2.81	
Average				3.15		5.53		1.91
1910	20	1	5.08		7.52		1.48	
	21	1	3.05		6.61		2.16	
	22	1	2.76		5.92		2.14	
	23	1	2.61		6.35		2.43	
	24	1	5.78		6.59		1.14	
	25	1	3.58		6.02		1.68	
Average				3.81		6.50		1.84
1911	20	1	3.64		5.15		1.41	
	21	1	2.66		5.31		1.99	
	22	1	2.25		4.56		2.02	
	23	1	2.17		4.27		1.96	
	24	1	3.87		3.34		.86	
	25	1	3.87		3.15		.81	
Average				3.08		4.30		1.51
Average for 6-year period 1906-11				3.63		5.90		1.63

Note—Sandy clay soil. Water measured from weir box at an average distance of one-fourth mile from plats, applied under field conditions. Waste water from plats not measured.

It is noted that the greatest average total irrigation of 5.18 feet was given in 1907 with an average yield of 5.99 tons per acre or slightly above the average for the six-year period. During every other year the average total irrigation was between three and four feet, or averaging 3.32 feet.

The highest yield of 7.36 tons per acre was obtained in 1906 with a total irrigation of three feet of water, and the next highest yield of 6.5 tons per acre in 1910 with an average total irrigation of 3.81 feet of water.

Leveling land with a tailboard scraper on the Truckee-Carson Project.

The average results for the six-year period shows a yield of 5.9 tons per acre with a total irrigation of 3.63 feet. This gives a yield of 1.63 tons per acre-foot of water.

DUTY OF WATER ON ALFALFA UNDER FIELD CONDITIONS IN THE CARSON VALLEY, 1907. In 1907 the Experiment Station in co-operation with Irrigation investigations, United States Department of Agriculture, made a number of water duty determinations on the ranch of the Dangberg Land & Cattle Company in the Carson Valley. The following table shows the results of these determinations, including number of irrigations, depth of irrigation, yield per acre and yield per acre-foot of water:

DUTY OF WATER ON ALFALFA AT THE DANGBERG RANCH, CARSON VALLEY, 1907.*

Kind	No. of Irrigations Feet	Depth of Irrigation Feet	Date of Cutting	Yield per Acre Tons	Yield per acre-foot of water. Tons
FIELD No. 1—81.32 ACRES					
Alfalfa and Timothy, 1st crop	3	3.16	July 22-26	3.87	1.23
Alfalfa, 2nd crop	3	2.71	Oct. 4-8	2.46	0.90
Total...........		5.87		6.33	1.06 (Aver.)
FIELD No. 2—80.50 ACRES					
Alfalfa, 1st crop....	2	3.08	July 1-4	1.68	0.55
Alfalfa, 2nd crop....	2	2.24	Sept. 5-8	1.49	0.66
Total...........		5.32		3.17	0.60 (Aver.)
FIELD No. 3—102.66 ACRES					
Alfalfa, 1st crop....	3	3.40	Aug. 16-20	2.92	0.85
Alfalfa, 2nd crop..Used for pasture balance of the season.					
Total...........		3.40		2.92	
FIELD No. 8—50 ACRES					
Alfalfa, 1st crop....	3	2.94	July 22-23	3.4	1.16
Alfalfa	2	2.02	Sept. 19-20	2.4	1.18
Total...........		4.96		5.8	1.17 (Aver.)
Aver. for fields 1, 2 & 8		5.38		5.1	.95

*The yields shown in this table are the results of common practice on the Dangberg ranch, one of the largest cultivated ranches in the State.

The land represented by these fields was in a high state of cultivation, contained an excellent stand of alfalfa and was irrigated by the furrow method. The average results for fields 1, 2 and 8 show a yield of 5.1 tons per acre with a total irrigation of 5.38 feet, which gives a yield of .95 tons per acre-foot of water.

IRRIGATION INVESTIGATIONS WITH ALFALFA, 1915-17.

During the three-year period, 1915-17, experiments were conducted on the irrigation of alfalfa to compare the depth of application, water content of plant, proportion of leaves to stems, yield per acre and yield per are-foot of water, when irrigated at different stages of wilting.

In these experiments the water was measured into the plats through two-inch galvanized iron pipes and check plats were used to eliminate as far as possible any variation in soil. The alfalfa was irrigated by the border method of flooding, using small furrows about three feet apart to provide a more ready channel for the water to the lower end of the plats. The head of water was so regulated as to prevent any run-off. The results herein recorded are, therefore, based upon the actal water used by the plats under the varying conditions presented. The following table shows the results of the irrigation investigations with alfalfa for the three-year perior, 1915-17:

IRRIGATION OF ALFALFA

Average Results for the Three-Year Period, 1915-17.

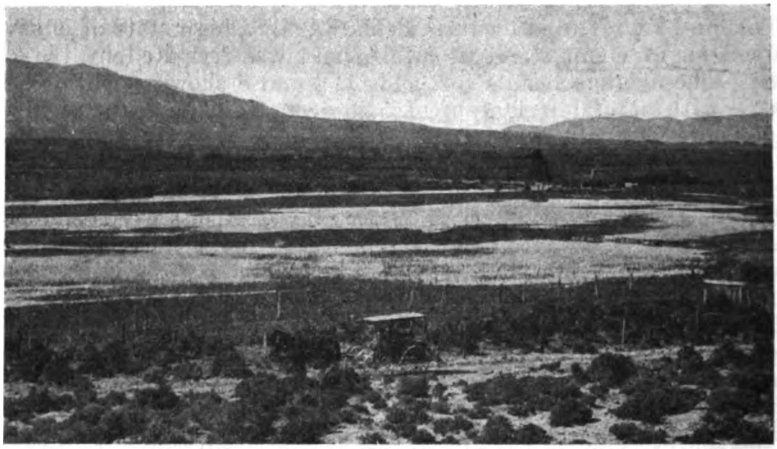
No. of Plat	Depth of Application Inches	Total Irrigation Inches	Total* Water Content Per Cent	Proportion of Leaves Per Cent	Yield per Acre Tons	Yield per Acre-Foot of Water Tons
Plants Never Allowed to Show Need of Water.						
2	6	66	84.2	37.15	6.06	1.10
5	9	63	86.0	36.40	6.06	1.16
8	12	80	81.4	37.05	6.63	.99
Irrigated When Plants Show Need of Water by Dark Green Color of Foliage						
3	6	44	78.6	39.85	5.34	1.50
6	9	45	81.2	40.10	5.67	1.51
9	12	56	77.8	38.00	5.61	1.20
Irrigated When Plants Show Need of Water by Dark Green Color of Foliage and Drooping Leaves.						
4	6	22	78.8	45.3	3.98	2.17
7	9	30	77.5	42.0	4.44	1.77
10	12	36	72.8	37.5	5.18	1.73

*Average results for 1915-16.

WHEN TO IRRIGATE ALFALFA

A too common practice of irrigating alfalfa in Nevada is to apply water to the crop at regular intervals with little regard to the actual needs of the crop for water, and to the possible injury to the soil by excessive irrigation.

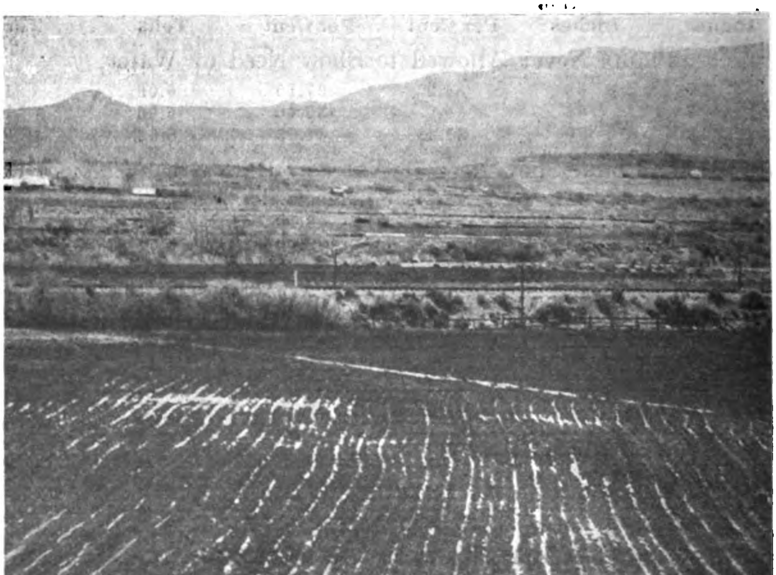
One of the chief objects of these investigations was to compare the different depths of irrigation at the different stages of wilting to determine the effect on the yield per acre and the yield per acre-foot of water.



An excess of water is used in this method of flooding.

This table indicates that for the most practical results, alfalfa is best irrigated when the leaves have turned dark green in color and begun to droop, using 12-inch applications. With such conditions, alfalfa produced an average of 5.18 tons per acre with 36 inches of water, thus giving a yield of 1.73 tons per acre-foot of water.

The use of 12-inch applications before the plants showed need of water produced the highest yield of 6.63 tons per acre with 80 inches of water, which gave a yield of less than one ton per acre-foot of water.



A minimum amount of water is used in the furrow method of irrigation.

The continuous use of the heavy irrigations may cause serious injury to the soil by producing a water-logged condition or washing down the soluble plant food below the reach of the feeding roots.

The soil on these plats is a sandy clay with considerable capacity for holding water. On lighter soils more frequent lighter applications will be required to prevent loss of water by percolation and the washing down of soluble plant food.

In these experiments alfalfa responded better than wheat or potatoes to heavy applications of water.

A home-made furrowing machine, commonly used in Nevada for furrowing alfalfa fields.

AMOUNT OF WATER APPLIED

These results indicate that under normal soil conditions, in Nevada, the most desirable amount of water for alfalfa will vary between 36 and 48 inches. The crop did not use economically more than this amount. Also continuous excessive irrigation lowers the producing power of the land.

The most economical use of water was obtained with an average annual total irrigation of 36 inches with 12-inch applications. The highest

yield was obtained with a total irrigation of from 6 to 7 feet of water in 12-inch applications, but was accompanied by a low yield per acre-foot of water and an inferior quality of hay, due to the large proportion of coarse leaves to stems.

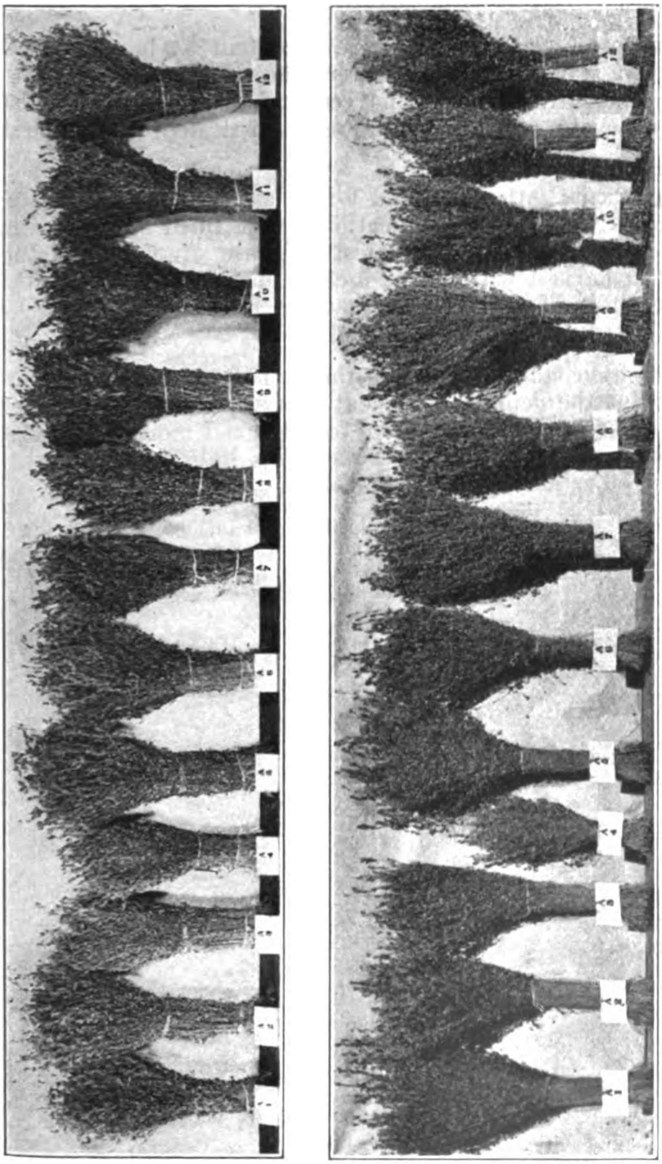
The average decrease in total depth of irrigation was accompanied by a relative decrease in water content of plant and yield per acre, but a comparative increase in proportion of leaves to stems and yield per acre-foot or water.

RELATION OF SOIL MOISTURE CONTENT TO TIME AND AMOUNT OF IRRIGATIONS. In conducting these experiments on the irrigation of alfalfa, soil samples were taken at regular intervals during the period of irrigation to determine the variations in moisture content in relation to the time of irrigation and the depth of each application. The following table compares the soil moisture contents before the first irrigation and before the second cutting of alfalfa, at different stages of wilting, with 6-inch, 9-inch and 12-inch applications:

AVERAGE PER CENT OF DECREASE BEFORE HARVEST IN RELATION TO THE SOIL MOISTURE CONTENT BEFORE THE FIRST IRRIGATION FOR THE THREE-YEAR PERIOD, 1915-17.

	TIME OF IRRIGATION		
Six-Inch Applications.	Irrigated before plants show need of water.	When plants show need of water by dark green color of foliage.	When palnts show need of water by dark green color of foliage and drooping leaves.
Total Irrigation, inches....	66	44	22
Yield per acre, tons.....	6.06	5.64	3.98
Yield per acre-foot of water, tons	1.10	1.50	2.17
Average per cent of decrease in soil moisture at harvest	12.7*	7.2*	6.1
Nine-Inch Applications.			
Total Irrigation, Inches...	63	45	30
Yield per acre, tons.....	6.06	5.67	4.44
Yield per acre-foot of water, tons	1.15	1.51	1.77
Average per cent of decrease in soil moisture at harvest	31.5*	4.2	23.3
Twelve-Inch Applications.			
Total Irrigation, inches...	80	56	36
Yield per acre, tons.....	6.63	5.61	5.18
Yield per acre-foot of water, tons	.99	1.20	1.73
Average per cent of decrease in soil moisture at harvest	4.2	8.9	35.4

*Average per cent of increase in soil moisture content at harvest.



Variation in height of alfalfa with different methods of irrigation. Above, first crop; below, second crop. Plats 2, 5 and 9, irrigated before plants were allowed to show need of water, with 6, 9 and 12-inch applications, respectively. Plats 3, 6 and 10, irrigated when plants showed need of water by dark green color of foliage, with 6, 9 and 12-inch applications, respectively. Plats 4, 8 and 11, irrigated when plants showed need of water by dark green color of foliage and drooping leaves, with 6, 9 and 12-inch applications, respectively.

An increase in soil moisture content at harvest is noted with the six-inch applications in the first two stages of wilting and with the 9-inch application in the first stage, due in part to the frequency of irrigation. The greatest increase occurred with the 9-inch application and a total irrigation of 63 inches.

The most uniform decrease in moisture content at harvest is noted in the third or last stage of wilting. Here the total irrigation and the as the decrease in moisture content at harvest and the depth of application as the decrease in moisture content at harvest and th depth of application become greater.

The yields per acre with the 6 and 9-inch applications at the second stage of wilting and the 12-inch application at the third stage of wilting show but little variation but the greatest decrease of 35.4 per cent in moisture content at harvest with the 12-inch application together with the high yield per acre-foot of water shows that this is the most practical and economical use of water of these three methods.

With the two other stages of wilting the variations are not so marked, but tend to bear out the general statement that when the total irrigation exceeds an average of from three to four feet, the soil moisture content at harvest increases or shows a slight decrease, thus indicating that the excess of water applied is not used economically by the alfalfa crop.

For additional information on irrigation practices in Nevada, see Bulletin No. 91 on "THE IRRIGATION OF WHEAT IN NEVADA."

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Bulletin No. 94 June, 1918

ONE-NIGHT CAMPS
vs.
ESTABLISHED BED-GROUNDS
On Nevada Sheep Ranges

By

C. E. FLEMING, B.S.A.,
Head of the Department of Range Management
Agricultural Experiment Station

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

148

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. JAMES F. ABEL (1917–1921), Chairman	Reno
Hon. JAMES W. O'BRIEN (1915–1919)	Sparks
Hon. JOHN J. SULLIVAN (1915–1919)	Reno
Hon. B. F. CURLER (1917–1921)	Elko
Hon. EDNA C. BAKER (1917–1919)	Sparks

OFFICERS

WALTER E. CLARK, Ph.D.	President of the University
Mrs. L. B. BLANEY, B.A.	Secretary
CHARLES H. GORMAN	Comptroller

STAFF

SAMUEL B. DOTEN, M.A.	Director and Entomologist
CHARLES S. KNIGHT, B.S.	Agronomist
GEORGE HARDMAN, M.S.	Assistant Agronomist
CHARLES E. FLEMING, B.S.A.	Range Management
N. F. PETERSON, B.A., M.A.	Assistant in Range Management
EDWARD RECORDS, V.M.D.	Veterinarian
LEWIS H. WRIGHT, V.M.D.	Assistant Veterinarian
JAMES EDWARD CHURCH, JR., Ph.D.	Meteorologist
C. ALFRED JACOBSON, Ph.D.	Chemist
STEPHEN LOCKETT, V.M.D.	Assistant Veterinarian
HARRY W. JAKEMAN, V.M.D.	Assistant Veterinarian
MAXWELL ADAMS, Ph.D.	Consulting Chemist
PETER FRANDSEN, A.M.	Consulting Biologist
C. W. LANTZ, A.M.	Consulting Botanist and Horticulturist
FREDERICK W. WILSON, M.S.	Consulting Animal Husbandman
VERNER E. SCOTT, B.S.	Consulting Dairy Husbandman
J. L. WEBB	Bureau of Entomology, U. S. Department of Agriculture
RUTH MILLER, B.A.	Secretary to Veterinary Department
Mrs. T. W. COWGILL, M.A.	Librarian
HESTER MAYOTTE	Secretary to Director

ONE-NIGHT CAMPS vs. ESTABLISHED BED-GROUNDS

INTRODUCTION

This bulletin reports the results of experiments during two seasons to determine (1) whether it is practical to handle sheep on summer ranges in Nevada without returning each night to an established camp; and (2) the effect of such a system of handling on the sheep and the range in comparison with the prevailing method of returning each night to a fixed bed-ground.

In Nevada the general method of handling sheep on the summer grazing ranges of the public domain is to make a permanent bed-ground to which the sheep are returned each night until all the forage within a radius of a mile to three miles of the bed-ground is consumed, when a new camp is established. Quite frequently, under this system of handling, the sheep are close-herded; dogs are employed more often than is good either for the sheep or the range; unnecessary trailing, running, and massing take place; the range forage is cut up and destroyed by the hoofs, and there is a material loss of flesh in both ewes and lambs.

In order than this loss of flesh and destruction of range might be reduced, a study was made during the summers of 1916 and 1917 to determine under Nevada conditions what the advantage to the ewe and her lamb would be and what difference it would make in the carrying capacity of the range if the sheep were allowed at all times to graze contentedly, openly, and quietly, and were allowed to bed down wherever they were overtaken by night instead of being driven back each night to a permanent bed-ground.

Three flocks were studied under each system during the summers of 1916 and 1917. The details, results, and conclusions for the two systems follow:

THE KIND OF RANGE WHICH WAS STUDIED

In order to compare results from the two systems we had to find a good big piece of range which was very much the same all over, and make our trials there. The grasses and plants had to be the same; they had to be about as thick on one part of the trial range as on the other. The country had to be about the same on one part as the other, with the same amount of water on both. The range selected was an open grass-land region, a rolling hill country where the sheep could get at all of it easily. The grass was about the same on all of it, and the kind of country and watering-places were very much alike. It was an ideal range on which to try out the two systems of camping.

The forage was made up mainly of grasses, with a scattering growth of weeds and browse. There was very little timber, only a few scattered patches of aspen, which were used by the sheep to good advantage for shade during the heat of the day. On the average about seven-tenths of the surface of the ground was occupied by plant growth consisting of possibly 75% grass and 20% weeds and 5% browse. About 7% of the forage was not utilized. Because it was an exceedingly uniform range, any differences in carrying

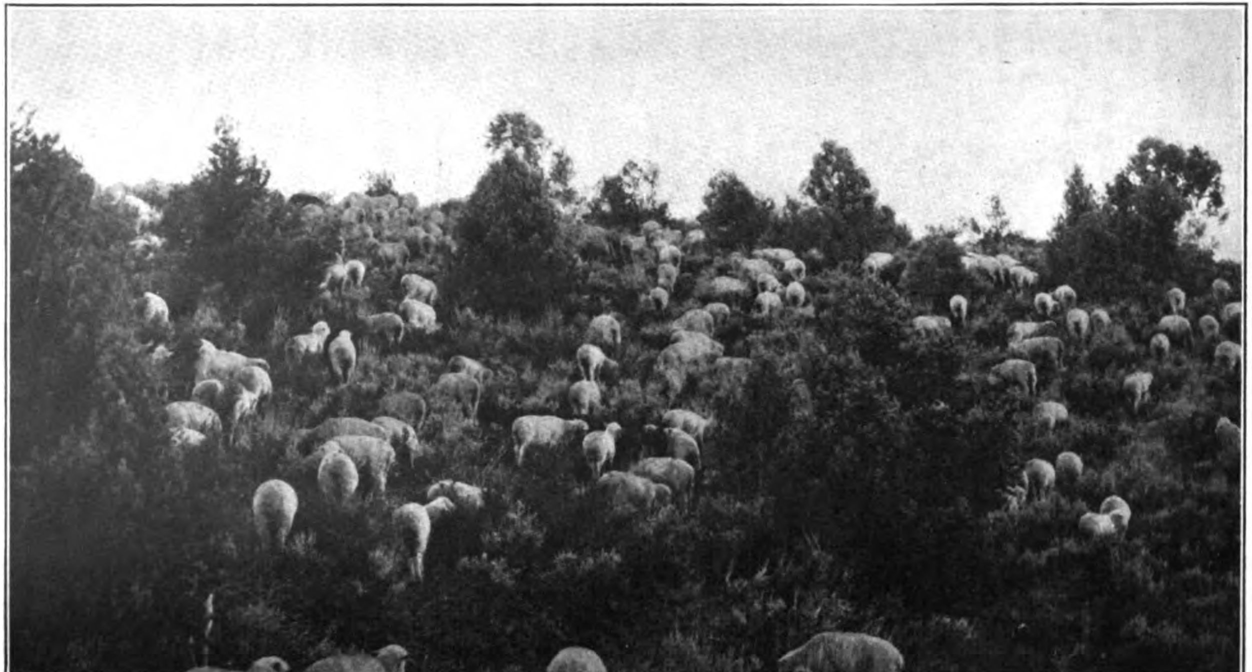


Figure 1. Sheep grazing openly, quietly, and contentedly. Heavier lambs, fewer cripples, and fat ewes will result at the end of the summer grazing season.

capacity can only be attributed to the methods used in handling the sheep.

BREEDS OF SHEEP USED

The ewes handled under the various tests were mainly fine-wools, with a good many showing the long-wool characteristic of the Lincolns and Cotswolds, or the typical black and brown faces of the Shropshire and Hampshire. However, the foundation blood consisted mainly of Merino and Rambouillet.

HERDING QUALITIES OF THE VARIOUS BREEDS STUDIED

From all observations made during the two seasons, it appears that the fine-wool sheep taken collectively are more easily herded and handled than either the mutton or the coarse-wool breeds.

The western sheepman has never developed a type of sheep which would meet his own special needs. He has taken the various breeds which have originated from the peculiar standards of the various breeders, from environment, and from the varying character of climate, forage and soil, and adapted them as best he could to meet his own varied economic conditions. Because of this intermingling of breeds there are few flocks of pure-bred sheep on our western ranges. Consequently the wool is far from being uniform. the herding qualities vary in different flocks, the lambs produced are decidedly uneven, and the ability to withstand severe winters varies according to the breed of the sheep being handled. However, sheep especially adapted to western range conditions must have the ability to stand severe storms, with little or no protection, and to maintain themselves during periods of drought and starvation; they must be good shearers, and must have an inbred tendency to herd well without unnecessary trailing and straying.

The fine-wool sheep, therefore, have a big advantage on our western ranges over most other breeds because the environment under which they were developed and produced gave them a pronounced ability to sustain themselves on scanty coarse feed.

As rustlers they are entitled to first place. On account of this active rustling habit, they are more particularly adapted than other breeds for grazing on our rough broken ranges where they are forced to cover a large area in order to get their feed. Further, sheep on our Nevada ranges are kept to average age of seven to eight years, and the fine-wool breeds will hold their wool better than any other breed to this age. The mutton breeds soon become light shearers, the wool getting especially thin over the stomachs. Of all the breeds observed, the fine-wools utilized the range forage most efficiently; and their lambs, produced by crossing blocky mutton-bred sires, were the most promising on the range.

HERDERS

The herders in every instance were Basques. In Nevada practically all of the sheep are handled by this class of herders. As a general rule, after being given the proper instructions they are very reliable and conscientious shepherds. The herders who handled the sheep under observation all had more or less ability and displayed considerable energy, but they did not handle their flocks in the same manner. This difference in the methods of handling, offered an

Figure 2. Running the wool and mutton off the sheep. The lazy herder's way of herding. His lambs would weigh at the end of the season from 5 to 7 pounds more if all the unnecessary dogging and running were cut out.

excellent opportunity for working out comparative range-carrying capacity tests, and average daily gains made by lambs under the existing methods of handling sheep on our public domain range. The greatest difference in the methods of the various herders was that a few changed their bed-ground daily and allowed their sheep at all times to graze openly and quietly, while others close-herded their sheep and returned them each night to an established camp until all the feed within a radius of two to three miles was grazed off. Then the camp would be moved by the camp-tender and a new bed-ground made on some other part of the range. A comparison of the two systems follows.

ESTABLISHED BED-GROUND SYSTEM

When the animals are handled under this system a main camp is established to which the sheep are returned each night and bedded down. On this bed-ground with the herder they remain all night without any attention until early morning, when they commence to become restless, because their stomachs are empty and they are anxious to begin feeding. The herder must now be on duty to direct them toward the area where he wishes them to graze during the day.

BEDDING-OUT SYSTEM

Under the system just explained the sheep are returned to a permanent bed-ground each night, but with the bedding-out system they are allowed to bed down on a new area each night. This means a new bed-ground every day or a new bed-ground every third day in case of wet or stormy weather, when it would be impracticable to move camp. However, under Nevada conditions, there are but few nights during the summer when it is wet and cold, so that, practically speaking, it is entirely feasible to have a new bed-ground every night.

Under this system, rather than to graze the vicinity of a camp to full capacity and injure or ruin the range forage as under the old system, it is left in good condition and grazed again at a later date. The sheep are always on fresh feed, which allows them to graze during the cool morning and evening hours and to seek shade during the hot part of the day.

As soon as the sheep leave the bed-ground in the morning they immediately begin to spread out; some going in one direction and some in another. Some travel fast and others slow. In a short time if they are not checked they will have spread over a large area, and instead of being in a compact bunch, as they were when they left the bed-ground, they will have commenced to separate into smaller bunches.

At this stage, or even before, the lazy herder, or the one who uses the "close-bunched" herding system of handling, resorts to the use of the dogs and soon has the sheep rounded up into a more or less compact bunch. Dogging, running, and trailing go on all day until the sheep are returned at night to the bed-ground.

Some indifferent herders continually use their dogs in order to keep the tail end of the herd up with the leaders; but the energetic conscientious herder will keep himself moving around the outside of the flock constantly turning or retarding the leaders. This allows

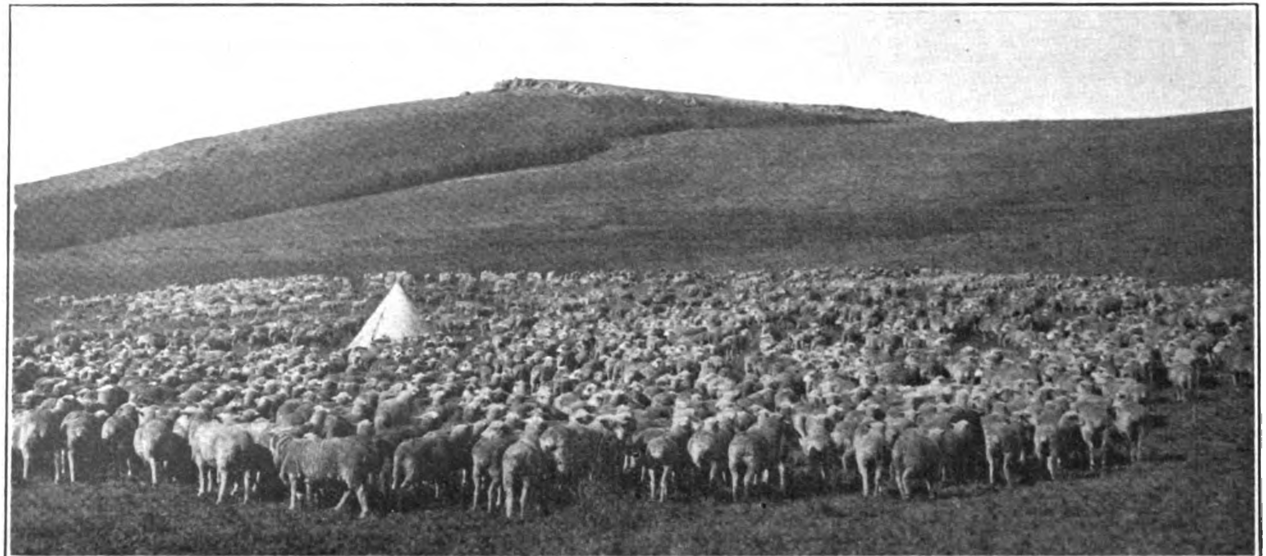


Figure 3. Sheep ready to bed down at evening on a new bed-ground. If the bed-ground is changed daily, the lambs will grow more rapidly, and the range will not be abused.

all the animals to graze contentedly with the greatest possible chance to exercise choice in the selection of forage. The sheep are allowed to bed down wherever they may be when night overtakes them.

If the heaviest range lambs are to be produced from a given piece of range, the system outlined above must be used. The ideal way of handling sheep on the range should approach as nearly as possible the manner of grazing within a pasture where the animals do the least amount of trailing from one place to another and where they are at all times allowed to graze openly and quietly without being disturbed. Of course, it is impossible under our present public domain conditions to handle sheep on the range under fence; but the pasturage system should be the ideal and should be approached as closely as possible. This means that tail-end herding must be done away with and the herding take place from the sides and front, the herder continually turning at all times the fast-trailing leaders. The slow-grazing sheep which are feeding in the rear of the flock will not then have to keep up with the fast-trailing leaders. This gives all the animals in the flock an equal chance to fill in the shortest possible time.

This is by no means a lazy man's way of herding, but it means an increase in the carrying capacity of the range, and means the production of heavier range lambs, fatter ewes, and fewer cripples. It simply means grazing with the least possible herding or actual driving. It allows the sheep to graze continually in the cool morning hours and to "buck up" during the heat of the day. It permits them to graze with quiet natural freedom, which favors the most efficient production of wool and mutton.

EQUIPMENT NECESSARY UNDER EACH SYSTEM

Under the old system of returning to an established camp each night the herder is usually supplied with two tents. One he uses for cooking and for storing supplies; the other he sleeps in. Frequently, however, the cook tent is very close to the bed-ground, so that he may use it if he wishes for cooking, storage, and sleeping. Generally he is not supplied with any means of transportation, depending entirely upon the camp-tender to do all of the moving of his camp supplies.

When the bedding-out system of one-night camps is used, the herder must have a horse or a burro on which he can lash his tent, bed, and provisions every day for transportation to the newly established bed-ground. A burro will carry the average summer-weight bed all day and never feel any discomfort; and, further, he will graze as one of the sheep. He is a very hardy inexpensive animal and will graze almost any area where sheep will feed. On some ranges the herders carry their beds on their backs to the new bed-ground. However, on most ranges it will pay a lot better to use a burro.

The most practical tent for the herder is a tepee. In heavy storms it gives the best protection, and when transported it is very easily taken down and set up. It is light in weight and not at all bulky. Possibly the most convenient way of carrying bed and tent is simply to take down the tepee in the morning, lash it on the burro, turn him

Figure 4. All day the burro carries the bed and tepee, grazing as one of the flock. At night the burro, the sheep, and the herder bed down wherever they are on the range. Open grazing and one-night camps mean increased profits to the owner, more mutton and wool for the Nation, and little abuse to the range plants.

loose with the sheep and let him graze along with them until they are ready to bed down for the night. A few herders prefer to wait until the sheep are almost ready to bed down; then go and get the tepee from the old bed-ground and put it up where the sheep are to bed that night.

TIME REQUIRED TO CHANGE HERDER'S BED FROM ONE BED-GROUND TO ANOTHER

The actual time required to take down a herder's tent and lash it on the back of the burro varies, but with the experienced herder it should not exceed much more than ten minutes. It can be done in less time than this, but for several mornings this was the average time for one herder who was not hurrying. It takes a little longer to take the tepee off the burro, spread it on the ground, put it up,

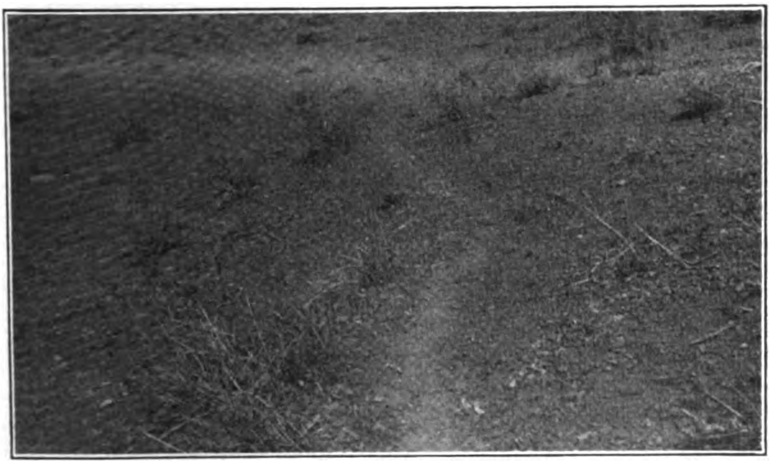


Figure 5. Sheep, when returned to an established camp night after night, eat off and destroy all forage in the immediate vicinity of the bed-ground. Note all that is left is rocks, sticks, and trails. Is it any wonder that the range is being ruined?

and make the bed. However, the entire operation of changing the bed from place to place should not take more than thirty minutes. Most of the time during the summer when there is no danger from storms the tepee is never put up, the herder merely using it as a protection to his bed.

TIME CONSUMED IN TRAILING TO AND FROM AN ESTABLISHED CAMP

Under the old system of returning to a permanent bed-ground each night the herder is forced to trail his sheep rather long distances, getting them to fresh feed each morning and then back again at night to the bed-ground. By actual time, it took one herder after he had been at one camp for six days, one hour and twenty-five minutes to return his sheep to the bed-ground; on the seventh day it took him one hour and thirty-five minutes; on the eighth day one hour and thirty-eight minutes, and on the ninth day the camp was

moved. It took him much longer to get the sheep on fresh feed in the morning than to return them to the bed-ground at night due to the fact that the sheep would graze on areas over which they had been before and consequently traveled much more slowly. However, as soon as they commenced to fill they trailed much faster and would soon reach fresh feed. The above figures approximate the average time consumed in the daily trailing to and from an established camp for a number of nights in succession. The long trail each morning and night works the greatest hardship on the sheep because they are allowed to graze but little, at a time when they are most anxious to feed; and in the evening the herder is usually very anxious to get back to camp and cook his supper, and consequently trails them in just as rapidly as possible by whistling, shouting, and the use of his dogs.

For range sheep, more especially lambs, to make the best gains, they should be allowed to graze during the cool evening and morning hours. This is not done when they are forced to trail over range which has already been grazed, as is always the case when the established bed-ground system is used. If they are not forced to make the long daily trail to and from an established camp, the general result will be a material increase in the carrying capacity of the range and a marked increase in the growth of the lambs.

SALTING

Too much emphasis cannot be placed upon the importance of giving the sheep a regular and liberal amount of salt. When the sheep are returned each night to an established camp it is comparatively easy to put sufficient salt at one time on the bed-ground to last them for five or more days. However, even under this system some herders do not salt their sheep more often than once a week, which is entirely too seldom. The best results are obtained when the sheep are given a little salt each day. When the camp is being moved daily this is more or less impracticable. Notwithstanding, they should be salted every three days. This will, in most instances, keep their appetites normal. As soon as sheep become salt-hungry they become restless and will eat many plants that normally they will not touch. A perverted taste is developed, and, of course, with this abnormal taste many cases of poisoning take place which could be avoided had the sheep been regularly salted. The best salt to use is the fine table salt, next to this the crystalline dairy salt. The rock salt is very unsatisfactory, for the reason that it takes a sheep a long time to get an amount sufficient to satisfy its wants. Further, this salt is very hard on the teeth of the sheep.

There are several ways of distributing salt to sheep on the range. One of the most common is to scatter the salt in several small piles, fifty to a hundred in number, on the bed-ground, the number of piles depending on the size of the flock. This will give all the sheep a chance to get at the salt without unnecessary crowding and will allow each sheep to get the proper amount. A much less common way is to have five or six galvanized tubs which will nest in each other (Figure 6). These tubs waste no salt, and are light and easily

transported. An excellent way of salting on the range to reduce the loss of salt is by the use of canvas troughs as shown in Figure 7. These are made by sewing 12- or 14-oz. canvas together to form a trough approximately twelve feet long, at the end of which are attached wooden end-plates. These troughs are then stretched and anchored to the ground by means of stakes as shown in the illustration, or by means of a steel stake which is attached to the end-pieces and driven into the ground, making stationary the lower part of the trough, while the upper part is made solid by means of small guide ropes. A considerable amount of salt taken to the sheep camps is wasted on the salt grounds. After salt has been transported long distances by wagon and pack-horse it becomes quite expensive. The loss may be in part or entirely avoided by the use of simple devices such as those described.

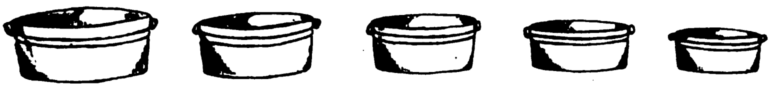


Figure 6. These small tubs nest each in another. They save salt and are easy to carry.

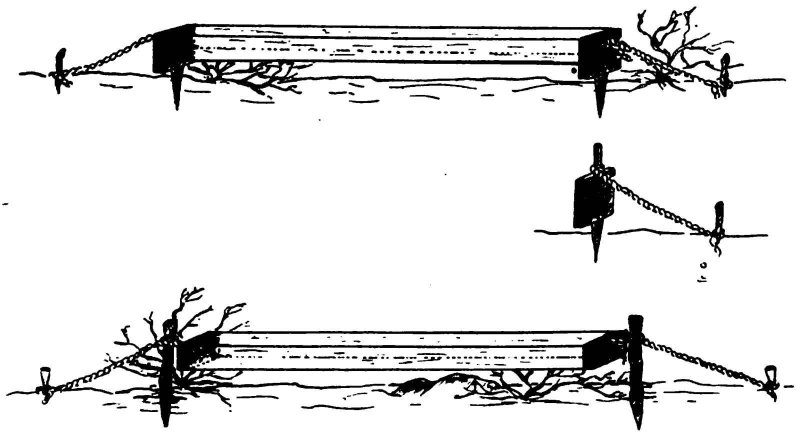


Figure 7. Portable canvas salting troughs for sheep.

When sheep are given salt at long irregular intervals it upsets, in a very pronounced manner, the digestive functions, causing scouring. The best results observed among several flocks were when the sheep were given one-half ounce daily—that is, three pounds to every hundred sheep. The sheep actually consumed this amount daily, and these figures do not take into account any waste. If the animals are salted in such a way that part of the salt is lost, then a larger quantity of salt per head must be supplied. The above figures are very easy to remember when estimating the actual amount of salt which must be consumed daily per head on the range in order to keep the appetites normal and to make the largest daily gain in flesh from the range forage consumed. This is the smallest amount that they should receive when grazing on the open range.

COMPARATIVE CARRYING CAPACITY OF RANGE UNDER BOTH SYSTEMS

Not only does the carrying capacity of the range vary according to the different kinds of plants making up the forage grazing types and the density of forage growing on them, but it also varies according to the manner in which the sheep are handled. In order to determine the difference in the carrying capacity of the range when the sheep were handled under the old system of returning to a permanent bed-ground and when they were allowed to bed down wherever night overtook them, six sheep ranges were selected for comparative study during the summers of 1916 and 1917.

The following table gives the carrying capacity of the range for each of the areas under observation:

Sheep Handled Under Bedding-Out System

Flock	Year	Ewes	Lambs*	Total sheep	Actual days of grazing	Total acreage grazed	Acreage utilized per day per sheep	Acreage utilized per 100 days per sheep
No. 1......	1916	1,656	1,492	2,402	73	3,413	.0195	1.95
No. 2......	1916	1,881	1,515	2,638	63	2,938	.0177	1.77
No. 3......	1916	1,485	1,273	2,121	62	2,669	.0203	2.03
No. 4......	1917	1,573	988	2,067	60	2,410	.0194	1.94
No. 5......	1917	1,883	1,007	2,386	49	1,776	.0152	1.52
No. 6......	1917	2,011	1,172	2,597	62	2,775	.0172	1.72
Average...	....	....	....	....	....	....	.0182	1.82

*Two lambs considered equivalent to one mature sheep

Sheep Handled Under Established Bed-Ground System

Flock	Year	Ewes	Lambs*	Total sheep	Actual days of grazing	Total acreage grazed	Acreage utilized per day per sheep	Acreage utilized per 100 days per sheep
No. 1......	1916	1,439	1,421	2,149	55	2,697	.0227	2.27
No. 2......	1916	1,604	1,583	2,395	67	3,915	.0244	2.44
No. 3......	1916	1,685	1,602	2,486	66	3,413	.0208	2.08
No. 4......	1917	1,825	1,100	2,375	62	3,050	.0207	2.07
No. 5......	1917	1,930	1,080	2,470	65	4,050	.0252	2.52
No. 6......	1917	2,012	820	2,422	88	5,578	.0261	2.61
Average...	....	....	....	....	....	....	.0233	2.33

*Two lambs considered equivalent to one mature ewe.

From the above tables the ewes and lambs handled under the bedding-out system utilized 1.82 acres per sheep per 100 days grazing season as compared to 2.33 acres per sheep per 100 days when they were returned to an established camp each night, a difference of 21.4% in favor of the bedding-out system in acres actually required to support a sheep for any given length of time.

This increase in carrying capacity when the two statements are compared may be accounted for by the facts that (1) the sheep are not forced to return each night over range already fully utilized, but are allowed to pass over an area only once and thus the loss of forage through trampling is reduced to a minimum; (2) a given area

of range is not fully utilized at one time, but is regrazed at a later date, thus permitting the plants to put forth fresh leaves after once being cropped, instead of being completely eaten to the ground, which materially impairs the vitality of the plants for any future growth during that season; (3) when allowed to graze openly and quietly they are spread out in open formation and only a few hoofs, at most, will strike any given plant, which minimizes injury to the plant from hoofing; (4) less waste of forage takes place, for sheep trail less when choice feed is available; (5) there is less packing of the soil; packing causing it to dry out more rapidly with the consequent retarding in the growth of the range plants, and (6) a more uniform utilization of the area grazed takes place as it eliminates overgrazing and extremely close grazing in the immediate vicinity of the established bed-ground and incomplete utilization of more distant areas.

If a certain area of sheep range has a carrying capacity of 5,000 head under the established bed-ground system, then with a saving of 21.4% of vegetation which actually takes place where the bedding-out system is used, that same range, under the latter system, would have a carrying capacity not of 5,000 head but of 6,070. If such a conservation of forage could be effected over all of our public domain range, it would mean a tremendous increase in the carrying capacity of our summer grazing ranges, or, in other words, a much larger number of stock could be ranged than at the present time. Even if no more animals were run than at the present time, the present depleted public domain ranges would have a chance to revegetate by native seeding.

GRAZING UTILIZATION UNDER EACH SYSTEM

In order to determine the degree of utilization of the range when the sheep were returned to a fixed bed-ground as compared with the system of being allowed to bed where night overtook them, a series of small areas or quadrates six feet square were selected on two different ranges before the sheep began to graze them and the total number of plants on each of the small areas listed. At the close of the grazing season the plants were again recorded in order to determine the number removed or the degree of utilization of forage which had taken place for each range. The two areas selected for this test were open rolling country where it was possible for the sheep to utilize every portion of the range with ease. The main type of forage growing on these ranges was grasses and weeds having a very uniform density over all of the area grazed.

The quadrates on the range where the sheep were returned to a fixed bed-ground were laid out from a central camp so that a quadrate was found in the ¼-mile, ½-mile, ¾-mile, 1-mile, 1½-mile, 1¾-mile, and 2-mile zones, respectively. At the close of the season 97% of the plants had been removed in the ¼-mile zone, 95% in the ½-mile zone, 93% in the ¾-mile zone, 68% in the 1-mile zone, 48.4% in the 1¼-mile zone, 20.5% in the 1½-mile zone, 14.1% in the 1¾-mile zone,

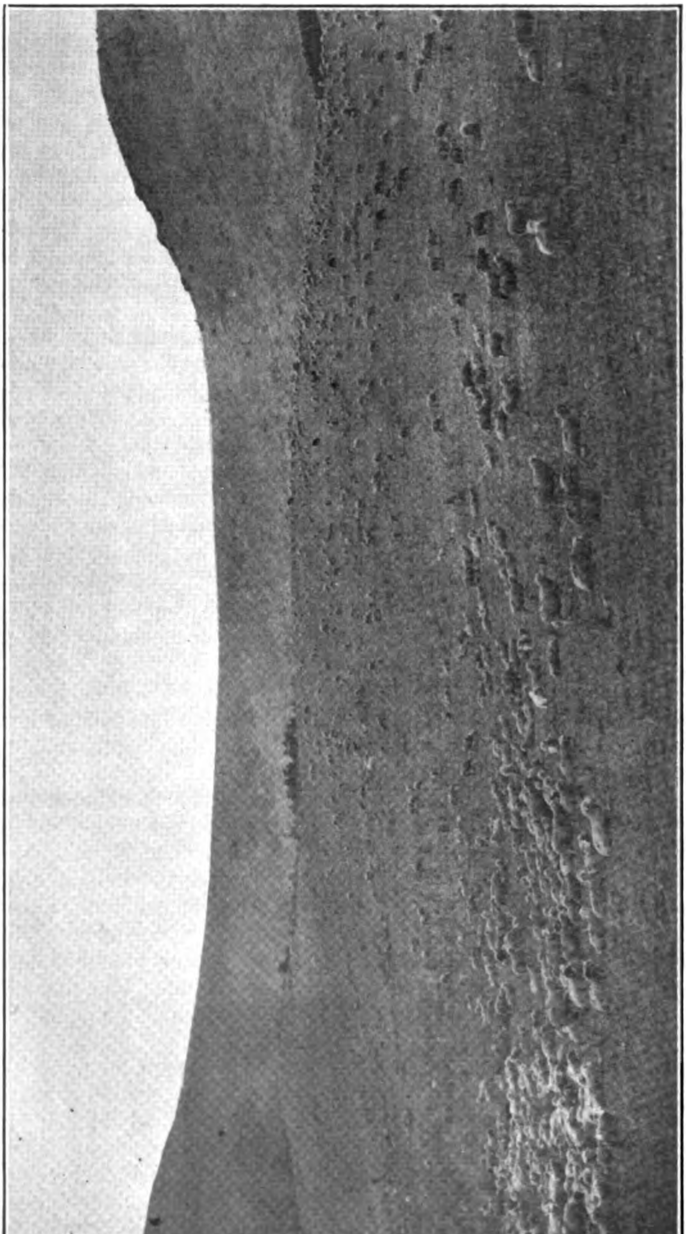


Figure 8. Ideal system of herding on the range. Some are standing, some lying down, others quietly grazing. This means that more sheep can be grazed on a given area and more wool and mutton produced.

and in the 2-mile zone no appreciable utilization had taken place. Thus, there was overgrazing in the immediate vicinity of the bed-ground and no use made of the range two miles away.

On the range where the sheep had been allowed to select their bed-ground each night, out of the 32 quadrates established an average of 84.4% of the plants had been removed from each quadrate, and thus a very uniform utilization of the entire area had taken place, only 15.6% as an average of the forage being left ungrazed. On this range no area was completely grazed at one time, but was left to be regrazed at a later date. As a result, no injury was done to any part of this range, while in the case of the range where the sheep were returned to a central camp the range was badly abused and overgrazed in the vicinity of the bed-ground. Of course, the percentages given will vary with each different range and even with the same range, depending on the herder and the length of time the sheep are on the range, the climatic conditions affecting the growth of the forage plants, and the size of the flock. However, they do give comparative figures which illustrate admirably the fact that the range forage may be efficiently utilized or badly abused simply by the manner in which the sheep are handled.

There can be no question that the carrying capacity of the range, where equal and uniform grazing takes place, is materially greater than where certain portions are injured by overgrazing and other portions scarcely two miles from the central camp are not used at all.

Where the sheep graze on a different area each day, the plants are allowed to go to seed. Ordinarily this would not take place if all the forage had been removed at one time as it is around a fixed bed-ground. Thus, not only is there a material saving in forage, due to the elimination of waste through trailing and overgrazing, but the carrying capacity of the range may even increase each year because the plants already found on the range are allowed to go to seed.

COMPARATIVE GAINS MADE BY LAMBS UNDER EACH SYSTEM

In order to determine the effect of each system upon the growth of lambs, twenty average individuals were chosen from each flock, weighed at the beginning of the grazing season and again at the close. The comparative gains made by the various groups of lambs are given in the following tables:

Gains Made by Lambs Under Bedding-Out System

Flock	Year	Actual days of grazing	Average weight at—		Gain per head	Average gain per day
			Beginning	Close		
No. 1	1916	73	42.3 lbs.	70.0 lbs.	27.7 lbs.	.380 lbs.
No. 2	1916	63	45.5 lbs.	69.1 lbs.	23.6 lbs.	.375 lbs.
No. 3	1916	62	43.8 lbs.	66.0 lbs.	22.2 lbs.	.359 lbs.
No. 4	1917	42	45.2 lbs.	61.5 lbs.	16.3 lbs.	.390 lbs.
No. 5	1917	49	47.4 lbs.	64.3 lbs.	16.9 lbs.	.345 lbs.
No. 6	1917	62	47.0 lbs.	68.7 lbs.	21.7 lbs.	.350 lbs.
Average		58.5	45.2 lbs.	66.6 lbs.	21.4 lbs.	.3665 lbs.

Gains Made by Lambs Under Established Bed-Ground System

Flock	Year	Actual days of grazing	Average weight at— Beginning	Close	Gain per head	Average gain per day
No. 1	1916	55	52.0 lbs.	67.0 lbs.	15.0 lbs.	.273 lbs.
No. 2	1916	67	33.6 lbs.	53.8 lbs.	20.2 lbs.	.302 lbs.
No. 3	1916	66	38.1 lbs.	60.4 lbs.	22.3 lbs.	.338 lbs.
No. 4	1917	62	36.2 lbs.	57.2 lbs.	21.0 lbs.	.340 lbs.
No. 5	1917	65	30.4 lbs.	51.7 lbs.	21.3 lbs.	.328 lbs.
No. 6	1917	68	35.1 lbs.	56.5 lbs.	21.4 lbs.	.315 lbs.
Average		63.8	37.5 lbs.	57.7 lbs.	20.2 lbs.	.316 lbs.

From the above tables the lambs grazed under the bedding-out system made an average gain of .3665 of a pound per day as compared to an average gain of .316 of a pound when handled under the system of returning to an established bed-ground, or a difference of .0505 pounds per head per day in favor of the lambs grazed under the bedding-out system. This appears to be a rather unimportant difference; yet when it is applied to the growth of a lamb for a grazing season of 100 days it represents an increase in the weight of the lamb by 5.05 pounds, as compared to a lamb that is herded under the system of being brought back to an established camp each night. For a flock of 1,500 lambs it means a net increase of 7,575 pounds.

On January 1, 1917, the statistics show that there were 1,340,000 sheep within the State of Nevada. Assuming that 20% of this number are yearlings, bucks, and immature animals, it leaves 1,072,000 mature breeding ewes. The 1,072,000 breeding ewes should under ordinary range conditions produce a crop of 80% docked lambs or 857,600 lambs to go onto the summer grazing ranges. It is highly improbable, but say that one-half of these lambs are now being run under the best methods of handling, so as to produce the maximum growth in the lamb during the average summer grazing period. Now, if by improved methods of handling the weight of each lamb can be increased for the other one-half by 5.05 pounds, as shown by the figures of the preceding tables, the total increased production for the State, over what it is now would be 2,165,440 pounds of mutton for the same amount of range forage utilized. If the increased production per lamb only amounted to 2 pounds, the total increase would be extremely important.

The increased money value at 14 cents per pound for a flock of 1,500 lambs would amount to 1,500 times 5.05 pounds times .14 or $1,060.50. This would represent just that much more profit to the sheep owner and would go a long way towards paying the summer operating expenses of a band of ewes and lambs.

The above increase in the weight of lambs when handled under the bedding-out system is primarily due to the following factors: (1) The ewes are on fresh feed every day with many different kinds of plants to select from, and, as a consequence, their milk supply is proportionately higher than the ewes which are forced to eat feed which has been already grazed over or feed which requires one to three miles trailing each day in order to utilize it; (2) the loss of time and energy consumed in trailing from an established camp is

entirely eliminated; (3) the ewes and lambs are in most instances allowed to graze at all times just as openly and quietly as possible. giving them the greatest possible range freedom in the selection of their feed with the least amount of dogging, trailing, and running taking place, and (4) the ewes are allowed to choose range forage conducive to the greatest milk supply and production of wool and mutton.

MILK PRODUCTION OF EWES AS AFFECTED BY TYPE OF RANGE FORAGE

The daily milk yield of the ewe has a very marked influence on the growth of the lamb. When a lamb is first starting out in life it takes from its mother considerable fat, which is known on the range as "mother tallow." It makes its most rapid growth during the early period of its life, and the growth of the first month or six weeks is mainly controlled by the supply of milk produced by the ewe. After this period has passed the lamb gradually begins to eat appreciable amounts of forage, so that it is not nearly so dependent upon its mother.

The amount of milk produced by the ewe varies with the different breeds, with individuals of the same breed, the manner in which they are handled, and the kind of forage they are forced to graze. Ordinarily sheep prefer succulent weeds and will make the greatest improvement on this type of forage. A grass range is used most effectively when it is grazed by cattle. In order to determine what effect different types of range forage would have on the production of milk, two ewes and lambs of Rambouillet breeding were selected for study. The lambs were kept away from the ewes except at stated intervals when they were allowed to suckle their mothers. The ewes were first grazed on a range where the feed was mainly grasses and which was becoming coarse and more or less dry. The average milk production of the ewes on this type of range was 1.6 pounds per day. Shortly they were moved to a range which supported succulent grasses and weeds, and the milk supply immediately advanced to 2.1 pounds per day, an increase of .5 of a pound of milk over what it formerly was. The gains in the weights of the lambs were not considered, for it was necessary to keep the lambs in camp while their mothers were out on the range grazing, and this condition was so abnormal that they did not do well. However, it illustrates the importance of the various grazing types for the production of milk which in turn controls to a large degree the steady and fast growth of the lamb.

Thus, from the above it is clearly apparent that the continued rapid growth of lambs requires a range supporting an abundance of succulent forage. Camp-tenders and sheep-herders should therefore utilize their range and select their grazing camps so that the early range will be used first, keeping the higher camps and the areas along streams for use during the hot weather of July and August. Too often range which should be used later on in the season is grazed off early; and during the hottest period of the summer the sheep are forced to eat dry feed, oftentimes going without any shade. As a result, the milk supply of the ewe is materially diminished and the lambs do not make the growth that would have been

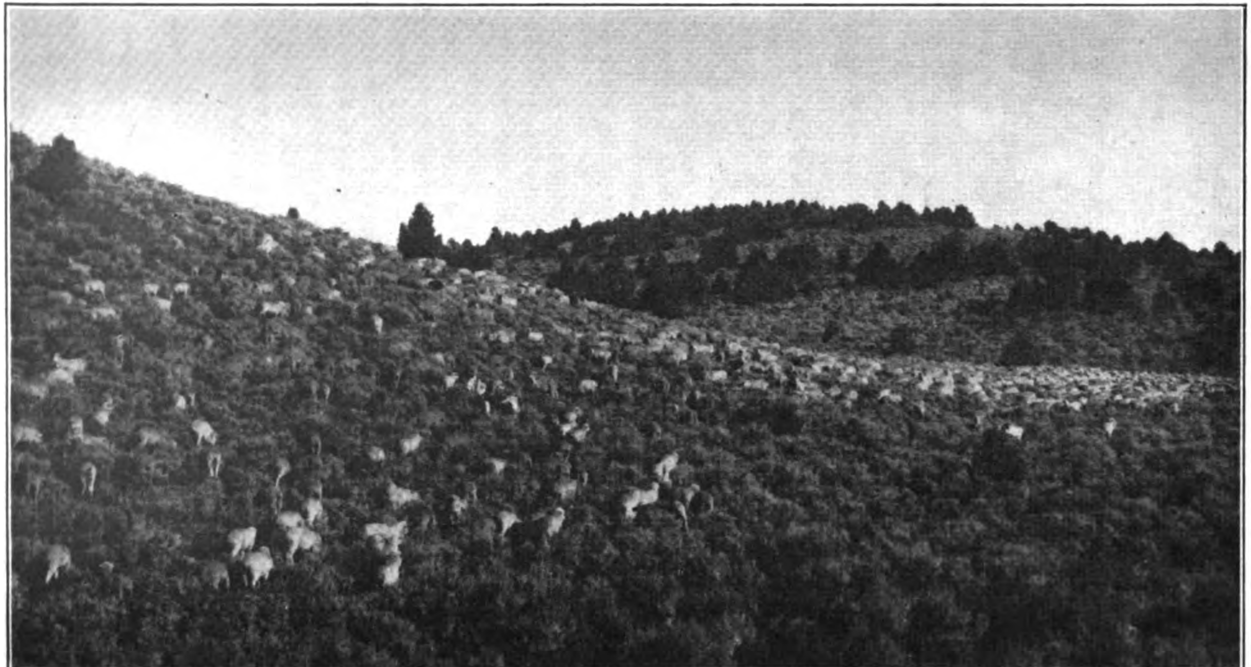


Figure 9. Tail-end herding taking place. Turn the leaders and do not try to make the slow-trailing sheep keep up with the fast-trailing leaders. Note massed formation at rear of band.

made if their mothers had been given the opportunity to shade up during the hot part of the day and had been allowed to feed upon the late-maturing succulent range forage at the proper time. The use of the range forage so that shade can be produced for the ewes and lambs during the hottest part of the grazing season, with green succulent feed near water, is not given the attention it should receive in the management of sheep on Nevada's ranges.

EFFECT OF TRAILING ON GROWTH OF LAMB

The effect of trailing long distances in order to get to and from fresh feed is well illustrated by the following case: A camp-tender had failed to move the herder's camp for eleven days and the range was badly overgrazed in the immediate vicinity of the camp, so that the ewes and lambs were forced to trail approximately 1½ to 2½ miles to get to fresh feed. During this period of long trailing to get to fresh feed three lambs were weighed in order to determine just what gains they were making when being forced to trail so far each day. The three lambs weighed 49, 55¾, and 56½ pounds, respectively. Each morning for four days they were weighed, and it was found that their average increase was .25 of a pound per day. With their mothers and the other animals in the flock they were moved and put on fresh green feed and the long trails eliminated.

They commenced to gain flesh immediately. Four days after the change of feed the three lambs had made an average daily gain of .32 of a pound, an increase of .07 of a pound per day over what they were making when compelled to make the long daily trail. This material increase in daily growth was caused by the change in the character and abundance and nearness of the feed. The long daily trails to fresh feed and back had prevented the ewes from giving the necessary amount of milk for the continued rapid growth of the lamb and had kept both ewes and lambs down in flesh; this was shown by the condition and appearance of their bodies. If this practise of maintaining a central camp from which and to which the ewes and lambs were forced to trail each day had been continued for a grazing season of 100 days, it would have meant the production of a lamb weighing on the average 7 pounds less than a lamb which had been allowed to bed down with its mother wherever they were on the range at night. Seven pounds each in the average flock of 1,500 lambs means 10,500 pounds of flesh and wool. This item is certainly worth considering, more especially when it is multiplied by the hundreds of thousands of lambs produced annually on Nevada ranges.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Bulletin No. 95 July, 1918

RANGE PLANTS POISONOUS TO SHEEP AND CATTLE IN NEVADA

By

C. E. FLEMING, B.S.A.,
Head of the Department of Range Management
Agricultural Experiment Station

SPANISH TRANSLATION

By

B. F. SCHAPPELLE, Ph.D.,
Assistant Professor of the Romanic Languages and Literatures
University of Nevada

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. JAMES F. ABEL (1917–1921), Chairman	Reno
Hon. JAMES W. O'BRIEN (1915–1919)	Sparks
Hon. JOHN J. SULLIVAN (1915–1919)	Reno
Hon. B. F. CURLER (1917–1921)	Elko
Hon. EDNA C. BAKER (1917–1919)	Sparks

OFFICERS

WALTER E. CLARK, Ph.D.	President of the University
Mrs. L. B. BLANEY, B.A.	Secretary
CHARLES H. GORMAN	Comptroller

STAFF

SAMUEL B. DOTEN, M.A.	Director and Entomologist
CHARLES S. KNIGHT, B.S.	Agronomist
GEORGE HARDMAN, M.S.	Assistant Agronomist
CHARLES E. FLEMING, B.S.A.	Range Management
N. F. PETERSEN, B.A., M.A.	Assistant in Range Management
EDWARD RECORDS, V.M.D.	Veterinarian
LEWIS H. WRIGHT, V.M.D.	Assistant Veterinarian
STEPHEN LOCKETT, V.M.D.	Assistant Veterinarian
HARRY W. JAKEMAN, V.M.D.	Assistant Veterinarian
RUTH MILLER, B.A.	Secretary to Veterinary Department
JAMES EDWARD CHURCH, JR., Ph.D.	Meteorologist
M. R. MILLER, B.S.	Chemist
MAXWELL ADAMS, Ph.D.	Consulting Chemist
PETER FRANDSEN, A.M.	Consulting Biologist
FREDERICK W. WILSON, M.S.	Consulting Animal Husbandman
VERNER E. SCOTT, B.S.	Consulting Dairy Husbandman
J. L. WEBB	Bureau of Entomology, U. S. Department of Agriculture
Mrs. T. W. COWGILL, M.A.	Librarian
HESTER MAYOTTE	Secretary to Director

RANGE PLANTS POISONOUS TO SHEEP AND CATTLE IN NEVADA

INTRODUCTION

In Nevada each grazing season brings the news that large numbers of live stock have been poisoned on the sheep and cattle ranges. This is due largely to ignorance on the part of the men actually handling the stock, since they fail to recognize our common poisonous plants. In very many instances the plant causing the loss was thought by the herder to be entirely harmless. It is hoped that the facts presented in this bulletin, with the illustrations, will help to meet this need of definite information about deadly range plants.

Most of the information presented in this publication was obtained from the following sources: (1) Feeding tests by Dr. Edward Records and Dr. Stephen Lockett, of the Department of Veterinary Science, University of Nevada, gave information about the symptoms shown by animals poisoned by eating lupine, rabbit brush, goldenrod, and other plants. (2) Chemical studies by Dr. C. A. Jacobson, of the University of Nevada, gave information about the nature of the poisonous matter contained in certain range plants and the part of the plant which is most poisonous. (3) Field observations made by the writer on ranges in Nevada and other Western States gave much information upon the growth and appearance of poisonous range plants and their importance to our livestock industry.

Because a large percentage of our sheep herders are foreigners who read no English, a part of this bulletin has been translated into Spanish. It is the sole purpose of this publication to give Nevada stockmen and herders practical information, in simple language, about the poisonous plants which are responsible for the greater part of our livestock losses, and to suggest methods of handling by which these losses may be reduced.

PRINCIPAL POISONOUS PLANTS OF NEVADA

Within the State of Nevada seven groups of plants cause most of the losses of live stock. They are: Death Camas, Larkspurs, Water Hemlock, Rabbit Brush, Lupines, Western Goldenrod, and the Locos. Those of less importance are: False Hellebore, Wild Cherry, and Aconite. Some of the groups contain several kinds or species, but, as their general appearance and poisonous properties are much the same, it is not important to distinguish them on the range.

Any of the first seven may fairly be called poisonous plants; that is, plants which cause serious illness or death, either immediately, or else after a time because of the cumulative action of the poison contained in the plant.

LARKSPURS

(*Delphinium* Spp.)

Description of the Plant.

There are two kinds of larkspur on the Nevada ranges; they are called tall larkspur and small larkspur, the latter being sometimes known as purple larkspur.

The tall larkspurs are erect branching plants from two to six feet high. The roots are large and deep set, more or less woody, supporting one or more crowns from which the stems are produced. A leaf is shown in Figure 1; all the divisions or main ribs spread out from the end of the leaf stem like a hand with outstretched fingers. The flowers of the poisonous larkspurs are of various tints of blue or purple, and have a very characteristic shape, due to the development of a spur-like structure on the upper sepal as shown in Figure 2.

Figure 1. Left-hand leaf, larkspur; Center, geranium; Right-hand leaf, monkshood.

The small larkspurs have single stems or at the most only a few. On the Nevada ranges they grow from 9 to 12 inches tall. The typical small larkspur is show in Plate I.

Distribution and Habitat.

Larkspurs are found on practically every range for cattle and sheep in the northern half of Nevada. Due to the extreme dryness in the southern half, the larkspurs are scarce, and do not cause serious losses.

The tall larkspurs grow in well-drained, moist, loamy areas along the creek bottoms, in the mountain parks, or in the clumps and groves of quaking aspen which are so common on the most valuable range in the eastern part of the State. They grow at altitudes ranging from 4,000 to 11,000 feet.

The small larkspur grows on range varying between 3,000 and 7,000 feet in altitude, where the soil is well drained, not excessively moist,

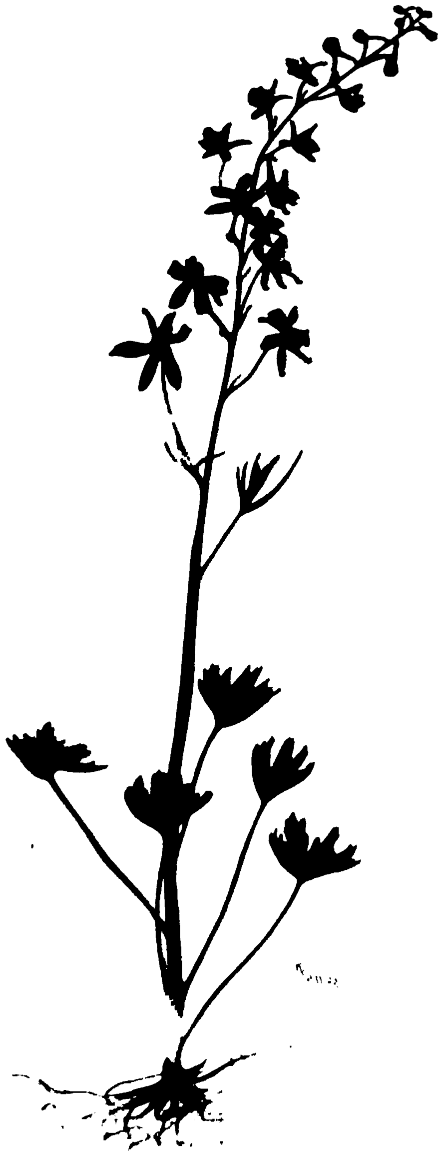


Plate I. LARKSPUR. (Consolida real.)

and usually in full sunlight. Thus our mountain foothills and the bordering sagebrush range form the typical country of the small larkspur. It does grow, however, to as high an elevation as the tall larkspur and is often a typical plant of the weed and park areas of the higher elevations. However, it is not much of a menace on the higher elevations because it is not abundant in the whole mass of palatable vegetation, and there is little chance that an animal will eat a fatal quantity.

Other Plants Which Are Commonly Mistaken for Larkspur.

The two plants with which the larkspurs are most commonly confused are the wild pink geranium and the aconite. When the pink geranium is commencing its spring growth it resembles the tall larkspur very closely. However, on the lowest part of the stem of the leaf of the geranium there are the two small pointed appendages which are shown on the center leaf in Figure 1; and these are not present on the leaf stem of

Figure 2. Left hand, flower of larkspur; right hand, flower of monkshood.

the larkspur. Further, upon squeezing the geranium leaf it usually produces the typical geranium odor which, of course, is not present in the larkspur leaf. The geranium leaf is usually covered with a growth of small fine grayish hairs, while the leaves of the larkspur are usually covered with a white surface coating easily rubbed off, much like that on plums and grapes.

The aconite, or monkshood as it is sometimes called, differs from the tall larkspur in that the upper leaves of the aconite plant are much more numerous and the leaves have very short stems as shown on the right-hand leaf in Figure 1. Instead of the flowers being spurred as in the larkspur, they are hooded as shown in the right-hand flower of Figure 2; this gives it the common name of monkshood.

Seasonal Growth.

No dates can be set for the time in the spring when the larkspur begins to grow. The tall larkspur on the lower elevations usually commences to grow during the latter part of April and, if the moisture conditions are right, it will last until late in August or early in September. For every increase in elevation of 1,000 feet the growth of

the larkspur plant is retarded by from ten days to two weeks. Thus, a kind of larkspur which might be in bloom on a 5,000-ft. range on July 15 would not be in bloom on a 6,000-ft. range much before August 1.

In a dry hot season, in Nevada, the larkspurs will start growth, blos-

Figure 3. Geranium. This plant is commonly confused with the tall larkspur during early spring.

som, and ripen their seeds much earlier than if the season were wet and cold; evidently climatic conditions have a very important influence upon the length of the time when larkspurs are capable of causing loss on the range.

On an average the small larkspur comes into bloom from six weeks to two months earlier than the tall larkspur. The small larkspurs are essentially early blooming and early maturing plants. They soon die to the ground after producing flowers and seeds, and cease to be dangerous late in the spring.

Animals Which Are Poisoned.

Sheep. From all field observations and feeding tests it can be safely stated that the larkspurs have no ill effects on sheep. On the other hand, they are more or less palatable, depending upon the variety and abundance of other species with which they are found growing.

Horses. Under ordinary range conditions horses do not relish larkspurs and they seldom eat enough at any one time to cause serious trouble.

Cattle. The larkspur in Nevada probably causes more loss among cattle than all other poisonous plants. Each year on most of our cattle ranges a large number of animals are fatally poisoned by larkspur.

Amount Necessary to Cause Death.

The amount of larkspur necessary to cause death varies with the age of the plant, the condition of the animal, and the individuality of the animal.

The larkspurs are most poisonous during early growth. During April, May, and June it takes much less of the plant to cause death than it does later when the plant is older. The tall larkspur is not poisonous after it has blossomed, and it may be reasonably safe to graze cattle on a range where this larkspur grows if the animals are turned on after most of the plants are through blooming. The seeds of the tall larkspur are its most poisonous part. However, cattle very seldom eat the seeds.

The small larkspur is poisonous through all of its growth; but immediately after blooming it dries up and disappears from the range, so that it is not dangerous after late spring.

Feeding experiments have shown that a steer must eat an amount of larkspur equal to from 2½% to 3% of its body weight in order to be fatally poisoned. An animal weighing 800 pounds would have to eat approximately 25 pounds of either the tall or the small larkspur. Evidentally the larkspurs are not violently poisonous, for to cause death a surprisingly large amount of the plant must be eaten.

Symptoms.

Sheep are never poisoned by larkspur and horses very rarely. Cattle poisoned by larkspur show the following symptoms:

On the range usually the falling of the animal is the first symptom which indicates that it has been feeding on the larkspur. However, most animals after going down the first time get up again and walk with the hind legs spread quite widely apart with a more or less staggering movement. There is little or no action in the joints of the legs, the walking movements being extremely stiff.

When the animal falls it goes down in a typical manner; usually the front legs give out first and the animal then supports itself from going clear over by resting the chin or the side of the head on the ground. In this position the hind legs are usually spread quite far apart. In severe cases the animal lies flat on the ground, raising the

head up and down; in less acute cases it will lie with the head erect. When standing there is a pronounced quivering or muscular trembling over the entire body, especially noticeable in the muscles around the nose and mouth. The spasmodic contractions of the muscles are also very clearly seen around the shoulders, hips, and flanks. There is frequently a belching of gas and an attempt on the part of the animal to vomit. There is usually considerable drooling or "slobbering." Constipation is almost invariably present.

Treatment.

A large percentage of the animals poisoned by larkspur on the range are already dead before they are discovered. Most of the animals which may be treated or cared for are the ones which are poisoned when being trailed from one range to another, or during the driving operations of a round-up.

After an animal goes down it should not be disturbed at all. If it has fallen on uneven ground the head should be placed higher than the body, to allow it to breath more easily. The rough-and-ready method of treating the animal by bleeding should be abandoned; for all experience on the range shows that bleeding only produces weakness and makes recovery less probable. If a steer tries to vomit we may usually safely conclude that it has eaten a fatal dose of larkspur and that nothing can be done to save it. However, the chances for recovery in most cases are good if the animal is allowed to remain just as quiet as possible and is given the following treatment, which was developed by Dr. C. Dwight Marsh, of the Bureau of Plant Industry, United States Department of Agriculture, who reports very satisfactory results from its use:

Physostigmin salicylate	1 gr.
Pilocarpin hydrochlorid	2 gr.
Strychnine sulphate	½ gr.

If losses are taking place each cowboy should be supplied with this remedy made up in tablet form. It can be secured from any druggist. The treatment is administered in the same way as though the animal were being vaccinated for blackleg. A four-dram hypodermic syringe should be provided for this operation. The tablet must be all dissolved and administered as a single dose. The dose should not be repeated. If possible, a bottle of boiled water in which to dissolve the tablets should be carried in the saddle bag. If it is not convenient to use boiled water, then use any clean clear water available. The essential thing is to get the tablet dissolved in clean water and injected under the skin of the animal.

Methods of Handling to Reduce Losses from Larkspur.

On many ranges the tall larkspur grows in small patches; it is these small patches that cause a high percentage of our losses. Where the larkspur is found growing on such well-defined areas, a practical method of preventing loss is by grubbing it out. The cost of grubbing will depend on: (1) The average wages of the men employed; (2) the cost of transporting men to the infested area; (3) the abundance of the plants and their distribution; (4) the nature of the soil, whether loamy, gravelly, or rocky; and (5) the type of vegetation the larkspur is associated with, whether weeds, creek brush, sidehill brush, quaking

aspen areas, etc. On the most difficult areas the cost of grubbing should not exceed $12 to $15 per acre, and the average cost should be approximately $5 to $8. Where grubbing can be done, it is much cheaper in the end than fencing or establishing drift fences because (1) there will be no waste of forage through nonuse; (2) the first cost of fencing will exceed the cost of grubbing; (3) the yearly cost of fence repair is eliminated; and (4) the rebuilding of the old fence when it is worn out is obviated.

The grubbing should be done so thoroughly that no plants are allowed to remain to reinfest the area worked. The larkspur should be cut off at least 6 inches below the surface of the ground, and the deeper the cutting the more effective will be the work. Not only the main roots but also all well-developed side roots should be taken out of the soil because if left in the ground they will produce new growth. A second grubbing the next year will be necessary, but the expense will be very light, and practically speaking all the plants will then have been eliminated from the range.

On certain ranges it is practical to first graze larkspur-infested areas with sheep. However, the sheep should be confined as closely as possible to the larkspur patches because if they graze the rest of the range there will not be much feed left for cattle. The cattle will then be forced to eat what they can find and they will graze all the larkspur patches again. The object of first grazing a larkspur-infested area with sheep is to remove the tempting larkspur plants and to give the other range plants a chance to grow. Also, when the larkspur is eaten off short before it is very large it is set back severely and will not make much growth that season. There is little or no use in trying to eliminate losses from larkspur from a range by grazing with sheep, unless it is done early in the spring. If it is not done at this time, the tall larkspur will grow to such a height that the sheep will only remove the lower part, and the plant will still be tempting to cattle; and, even though all the lower leaves are stripped off by the sheep, the upper leaves, flowers, and seeds will still be produced.

Because it takes so much larkspur to kill an animal, the chance of fatal poisoning will be greatly reduced if the larkspur patches are first grubbed out or grazed.

On all ranges there should be plenty of salt where the cattle can get it all the time. When larkspur is growing on the range, the salting grounds should be placed where they will be away from the larkspur patches. This will help to keep the animals from bunching and feeding where the larkspur plant is abundant. The salting grounds should be continuously changed, so that no part of the range will be badly overgrazed. After the larkspurs have blossomed the infested areas may be grazed with a minimum chance of loss taking place.

The choice of range plants is greatly influenced by the hunger of the animals. When the stomach is empty and the animals are very hungry they will eat many plants that they ordinarily would not touch. On a list of plants pleasing to the taste of cattle, the larkspur will not be among the first if there is much variety of forage present. When eaten in small quantities the larkspur causes no real ill effect, but if eaten in large quantities by hungry cattle some of them will undoubtedly get enough to cause death. Therefore, it should be a general practise never to drive stock over larkspur country while

their stomachs are empty. At all times cattle should have the greatest possible chance to select the plants they like. This means that fast trailing and hazing from one range to another must be cut out if losses from poisonous plants are to be kept down.

Herding Cattle Away from Larkspur Patches.

It is more or less impractical to herd cattle away during the entire grazing season from a larkspur range, but extreme care should be taken for the first two or three weeks that the animals are on the range; for during this period they are frequently in very poor condition, some even "skin poor." In this state they will eat any and all plants, including poisonous kinds, a good many of which they will not touch later, when they have mended or increased in flesh and their ravenous hunger has been satisfied. It should always be remembered that a poor, weak, hungry animal will eat many plants that it will not touch when well fed and in good condition.

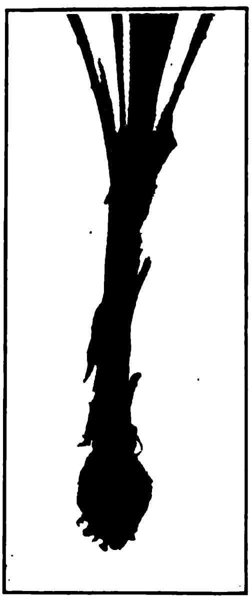


Figure 4. Death Camas bulb, showing thin, papery, brown coats.

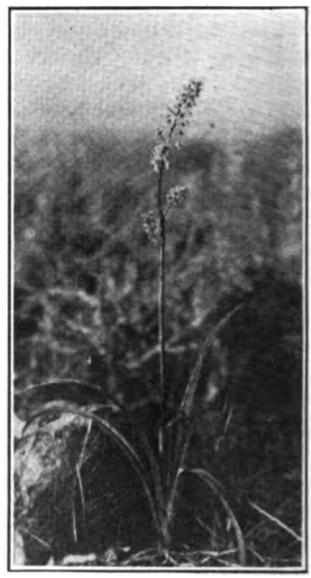


Figure 5. Death Camas, showing typical manner of growth on the range.

DEATH CAMAS

(*Zygadenus* Spp.)

Death camas is the name by which this plant is known in most places on the range, although it is sometimes called mystery grass, poison wild onion, poisonous sego, poison camas, and lobelia. Death camas, however, is the recognized common name and is the one which should be used.

There are several forms of death camas in Nevada; but they are all so nearly alike both in appearance and their effect upon range animals that one description of the general form of the death camas is considered sufficient.

Plate II. DEATH CAMAS.

Description of the Plant.

The death camas is an erect plant producing from five to seven fully formed grass-like leaves. It grows from a layered bulb set from 2½ to 6 inches deep in the soil. The bulb is from ½ to 1¼ inches thick and is covered with thin papery brown coats as shown in Figure 4. The leaves are from 6 to 18 inches long by a little less than ½ inch wide and are grass-like in appearance with a projecting ridge like the keel of a boat on the under side. They are much more succulent or juicy and thicker than the common grass leaves. There is no well-defined stem, the leaves appearing to rise from near the surface of the ground. The flowers are greenish-yellow or whitish, about ¼ inch across, and are produced in a flower cluster from three to ten inches long. The lower flowers ripen first and produce seed on the lower ranges during the latter part of May and the first part of June. The seeds which are formed do not grow until the next spring, when they produce a leafy grass-like plant which, however, has no bulb at first, but develops one later in the season. The second year this leafy grass-like plant sends up the typical death camas leaves and flower stock as shown in Plate II.

Distribution and Habitat.

This plant is to be found on practically every stock range in Nevada. It is more abundant in the northern part of the State than in the southern half. The areas upon which it grows are invariably moist, during the spring, and the typical grazing types in which it grows are: (1) sagebrush, (2) grass, (3) semimeadow areas, and (4) typical weed range where the vegetation consists largely of showy flowering plants. It does not grow in the shade under standing timber. It is found on practically all of the mountain foothills, the high open mountain park areas and in the sagebrush country of northern and western Nevada.

The time when death camas starts to grow in the spring varies with the season and also with different exposures and different soils. It is sometimes found as early as the middle of March. The plant makes its appearance first on sandy soils and on southern exposures. On the dark, loamy and clay soils its growth is much retarded, probably because these soils are moist and consequently they warm up less readily. If the weather is fairly warm the death camas commences to grow from ten days to two weeks after the snow melts out in the spring and it is soon high enough to cause loss. On the lower ranges by the latter part of June it has usually died down.

Plants Commonly Mistaken for Death Camas.

The death camas is most commonly confused with the wild onion. The bulb and leaves of the death camas, however, have no such smell as the onion. All the flowers of the wild onion grow out from one point at the tip of the stem, as in Figure 6, while the flowers of the death camas grow along the sides of the stem, as shown in Figure 6.

Animals Which Are Poisoned.

This plant is poisonous to all classes of stock, but more especially to sheep. Horses very seldom die as a result of eating it, though cattle are sometimes lost in the spring when they are turned out in very poor condition, or when they are being driven over badly infested areas. While being trailed they are usually extremely hungry and will nip and bite at all plants whether good or bad.

Losses of live stock from this plant are heaviest on a range that has been overgrazed. On such a range the death camas usually starts much earlier than the other plants because it has not been set back by the heavy grazing and consequently it has a greater amount of reserve food material with which to start plant growth. Further, the highly palatable and nutritious plants have all been removed, leaving only the undesirable and poisonous kinds. Consequently the probability of poisoning on such a range is greatly increased.

Parts of the Plant Which Are Poisonous.

All parts of the plant are poisonous. Ordinarily the part eaten is the leaves, which are equally as poisonous as the bulb. The seeds are

Figure 6. Death Camas on the left, and wild onion on the right.

also poisonous, but are very seldom eaten. The entire plant is poisonous throughout its period of growth.

Amount of Death Camas Necessary to Cause Death.

The amount of the death camas which must be eaten in order to cause fatal results depends upon (1) the individuality of the animal; (2) the weight of the animal, and (3) the condition of the stomach when the plant is eaten. A ravenously hungry animal is poisoned much more easily than one with a full or partly filled stomach. On the range a mature ewe weighing approximately 100 pounds must eat from 1½ to 5 pounds of the plant to cause fatal poisoning. For lambs it takes a correspondingly less amount.

Figure 7. When sheep graze openly and quietly on the range they show great care in the selection of the forage they eat. Thus the losses from poisonous plants are kept down to a minimum.

Symptoms.

When sheep on the range are poisoned by death camas the first symptom noted is that some of the sheep begin to straggle along with a decided indisposition not to graze with the other animals in the band. The head is dropped, and with most animals salivation or slobbering at the mouth takes place, accompanied by vomiting in the case of those badly poisoned, although many animals that have eaten a fatal dose do not salivate as freely as some which have eaten only sufficient to make them sick. The manner of walking is very irregular, both the fore and hind legs being affected, more especially the hind legs. When the animal falls it goes down head first, oftentimes resting for a short period on its knees. After the animal is down and cannot get up, the majority of them go off into a state of profound insensibility resembling very deep sleep, from which they cannot be aroused, and in this condition they die.

On a range in eastern Nevada, where practically the only vegetation was sagebrush and death camas, five steers were poisoned by death camas, and the symptoms were practically the same as those just given for sheep. However, cattle are very seldom poisoned by eating this plant because (1) it is not highly palatable and (2) it does not usually occur in a sufficient abundance so that the animals will be able to get a fatal dose.

Remedies.

There are no recognized remedies at the present time. The best treatment known is to let the animals entirely alone, disturbing them just as little as possible.

Methods of Handling to Reduce Losses from Death Camas.

When grazing openly and quietly on a range, as in Figure 7, sheep show great care in the selection of the forage they eat. However, when they are being trailed from one place to another they are deprived of the privilege of selecting and choosing their forage, with the result that without this chance of selection they eat everything that is not absolutely objectionable. If the death camas is on the range, and it usually is, they may eat so much of it that they get more of the poison than they can cast off, and death is the result. It should always be remembered that when a sheep is hungry it usually eats the whole plant it is grazing on at once; but only the tender and juicy parts such as the leaves and young stems, the most choice portions, are nipped off when it is not exteremely hungry or when it is allowed to graze with an opportunity of selecting its forage.

Thus, in order to avoid losses on a range, where death camas is growing, sheep should be so handled that they are never at any time extremely hungry. If they are being trailed from one range to another, it is best to allow them to graze for an hour or two in the morning just as openly and quietly as possible before starting to move them. This will allow all the animals to fill quite completely; and they will then use greater care in the selection of their forage for the remainder of the day. This would not be the case if they were started on the trail immediately after leaving the bed-ground.

Another very important point is to get the sheep off the bed-ground

just as early as possible in the morning. When a sheep beds down at night it is usually full and contented. By morning it is beginning to get rather empty, and the longer it is kept on the bed-ground the hungrier it becomes; it is then far more apt to be poisoned when it gets out on the range where the death camas is growing.

In most cases of death camas poisoning so far observed, the animals were poisoned during the forenoon. This is due to the fact that the palatability of the plant decreases as the stomach becomes full. Thus a plant which may seem to be highly palatable and to be relished during the morning hours frequently is not touched later in the day. This is quite true of the death camas. It is grazed chiefly during the early morning hours, and is seldom touched when the stomach begins to be full. Therefore it is highly important that the sheep should be so handled during the early morning hours that they will have the greatest freedom in the selection of their range forage; if possible, during this part of the morning they should be grazed on range free from death camas, or where it has only a scattering growth.

In Nevada the prevailing method of handling sheep, especially in the spring of the year, is to establish a main camp from which the sheep are grazed daily until all the feed in the immediate vicinity of the camp has been eaten out for a radius of two or three miles. This necessitates long daily trailing back and forth in order to get from range that has already been grazed to fresh feed. Thus the sheep trail over the same ground each day until all the forage on the range around the bed-ground is completely eaten off. This method of handling can only result in all plants being eaten, whether poisonous or not; for the most palatable ones are first grazed, and as these plants are removed the less palatable ones are left to be grazed including, of course, the death camas. In order to avoid losses resulting from these improper methods of handling sheep, they should be allowed to bed down wherever they happen to be when night comes. They will then always be on fresh feed in the morning. The variety of forage from which to choose will be much greater and the chance of poisoning will be greatly reduced, providing the animals are gotten off the bed-ground early in the morning and are allowed to spread out to graze openly and quietly, each ewe with her lamb. Close-bunched grazing, running, trailing, and massing should never be allowed, not only in order to keep the losses down, but also for the good of the ewe and her lamb and for the most full and effective use of the range forage.

After a sheep has been deprived of salt for a week or ten days it develops an abnormal or depraved appetite, with the result that it will eat many plants which ordinarily it would never touch. Therefore it is of the greatest importance that sheep be regularly and abundantly salted, so that the appetite will remain normal and the tendency to eat obnoxious or poisonous plants will be reduced. This means that they should have salt every day, and if it is not practical to salt daily, salt should be supplied at least every three days. A sheep under ordinary range conditions will eat approximately ½ ounce of salt per day, or 3 pounds per day to every hundred head. This does not make any allowance for waste, which, of course, varies according to the manner in which the salt is distributed to the sheep.

LUPINES

(*Lupinus* Spp.)

The lupines in Nevada are known by various common names, being improperly called blue bean, wild bean, wild alfalfa, blue pea.

Description of the Plant.

The lupines belong to the pea family, and are erect plants from six inches to three feet high, depending upon the species, the altitude, the soil, and moisture conditions. Most of the species in Nevada grow year after year from the same heavy deep-set roots, which produce several stems, the leaves of which are long stemmed and are divided into from four to fifteen small leaf divisions, all spreading from the end of the one leaf stalk. The flowers are borne in long clusters and are shaped like those of a pea. The colors are various shades of blue,

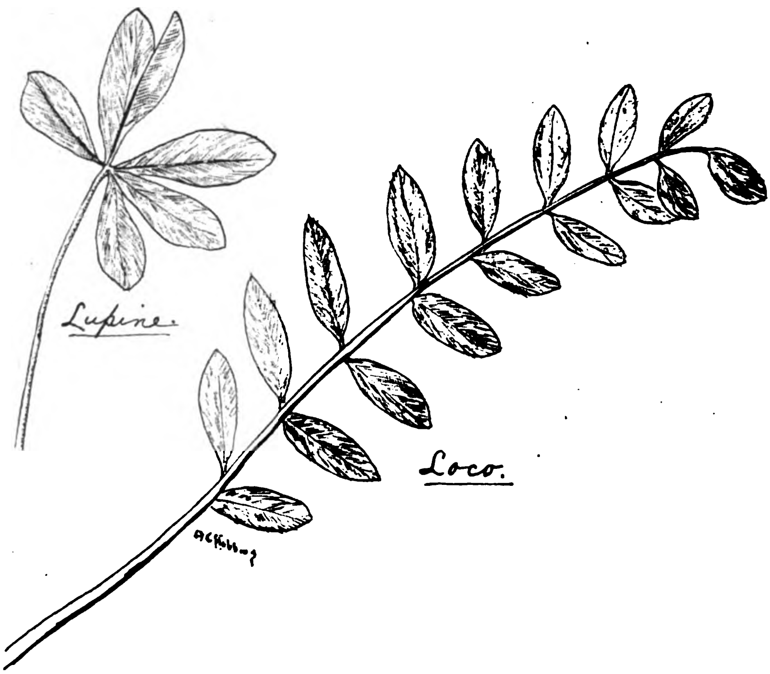


Figure 8. Showing the arrangement of the leaflets of the lupine on the left and a typical leaf of the loco on the right.

white, pink, or yellow. The pods contain one or more seeds and are usually covered by a growth of many small gray hairs. This hairy growth also is usually found on the upper surface of the leaves, giving the plant a typical grayish appearance. The lupine plant may be found in blossom from early summer until late fall. The largest number of flowers, however, are produced during July and August. A typical lupine plant is shown in Plate III.

Distribution and Habitat.

The lupine is one of the most widely and abundantly distributed of all the weeds or showy flowering plants found on the ranges of Nevada. It is found on practically all the low elevations and grows to an alti-

Plate III. LUPINE. (Lupino.)

tude of 10,000 feet. It grows on all types of soil, except those which are excessively wet or dry.

Plants Commonly Mistaken for Lupine.

The lupine is frequently confused by many stockmen with several plants, the most common of which is loco. However, the lupine may be readily distinguished by the arrangement of the leaflets, as shown in Figure 8, where they all arise from the end of the stem, while in the case of the loco the leaflets are arranged along the main axis of the leaf with one odd leaflet borne at the end.

Animals Which Are Poisoned.

Under certain range conditions this plant may be poisonous to all classes of stock. However, the heaviest losses take place when sheep graze upon it after the seeds have been formed within the pods. Horses are very found of lupine, but in order to be poisoned they must graze exclusively upon it for a rather prolonged period; this seldom occurs on the open range. It is not grazed with any degree of eagerness by cattle, yet losses have been reported on certain ranges in the late fall where this plant was the only one to be found on the range. Lupine poisons very few horses and cattle under Nevada conditions.

Sheep will always graze upon the grasses and succulent weeds before eating lupine. However, in the fall of the year when the other feed is becoming scarce and what little is left is dry, the lupine is usually still green and in pod. Sheep then graze upon it with disastrous results.

It seems that the lupine becomes more palatable after it has been frosted, but usually by this time of the year most of the seeds have dropped to the ground and of course there is then little or no danger from poisoning. Under such range conditions before sheep are allowed to graze on lands where lupine is common it should be carefully examined to see that it has no seeds in its pods. If there are still seeds in the pods, the sheep should not be allowed to graze upon it unless there are other plants on the range which will be eaten in preference to it.

All over Nevada there is a small weevil which feeds in the pods of the lupine and destroys the seeds. The pods may look as though they contain seeds, but upon close examination they are found to be seedless and of course the chances of poisoning taking place are very slight.

Parts of the Plant Which Are Poisonous.

Under certain range conditions which have not been definitely determined the leaves and the tops of the lupine plant have been known to cause death. However, the majority of the losses on the range have taken place after the lupine plant has blossomed and produced its seeds. (See Figure 9.)

In most cases after a sheep has eaten a large amount of the pods and seeds, it does not chew its cud before the typical poisoning symptoms appear. However, after the symptoms do appear the animal poisoned may die in a very short time or it may linger for one or more days before succumbing or getting entirely well. Thus, sheep may feed on a lupine patch one day and yet they may not be sick until the next day, when they may be grazing on country entirely free from any

or all poisonous plants. This accounts for the fact that losses often are reported on a range entirely free from all recognized poisonous plants. A question that often bothers the range man is: How can a band of sheep graze and fill up on lupines at one time with no ill effects; yet at another time when they do the same thing heavy losses follow? This may be explained by the fact that the poison from the lupine is excreted by the kidneys and is thrown off as soon as it is liberated; in order to cause death or ill effects the animal must get

Figure 9. A lupine plant in full pod. When the plant is in this stage most of the losses from poisoning take place.

more of the poison at one time than it can cast off immediately, with the result that the excess of poison is left in the system, causing the typical lupine symptoms and possibly death.

Amount of the Plant Necessary to Cause Death.

The amount of the plant that must be eaten before death will take place is an extremely variable quantity due to (1) the individuality of the animal; (2) the weight and general health of the animal; (3) the

species of plant that the lupines are associated with; (4) the condition of the stomach of the animal when the lupine is eaten; and (5) the kind of lupine eaten.

The most accurate feeding tests so far made show that it takes from ¼ pound to ½ pound of the seed to cause active acute poisoning or death in a sheep weighing approximately 100 pounds, and about 1½ pounds of the pods and seeds to produce the same serious effects. Very rarely are any animals poisoned by eating the leaves and stems, although some losses from this source have been reported.

Symptoms.

Probably the most common symptom of lupine poisoning is the manner in which the animal breathes. In acute cases of poisoning the animal breathes with difficulty and there is usually a frothing at the mouth. During these periods of difficult breathing it will throw itself about violently with great mental excitement, often running in no

Figure 10. Sheep in first stages of lupine poisoning.

definite direction, bumping into other anmals in the flock or against any obstruction that may happen to be in its way, such as brush, trees, or large rocks. When the roof of the mouth is examined a typical blue appearance is usually seen. A large number of animals die during these periods of extremely difficult breathing which make the animal appear as though it were in violent convulsions. On the other hand, some of the animals may go into a very deep sleep from which they never awaken. In less acute cases of poisoning the breathing is very labored and the animal may stand or lie down in a condition of deep sleep. The drooping of the ears is another typical symptom, usually accompanied by the animal pushing or butting its head against other near-by animals or objects. After an animal has passed through one of these periods of extremely difficult and labored breathing it often stands trembling all over. Figures 10, 11, 12, 13

show the characteristic attitudes assumed by a sheep poisoned by lupine.

Treatment.

There are no remedies which have given satisfactory results in treating a large number of sheep poisoned at the same time, as is usually the case on the range.

Methods of Handling to Reduce Losses from Lupine Poisoning.

Practically speaking, almost all the heavy losses which take place on the range as a result of sheep eating the lupines are due to mismanage-

Figure 11. Sheep in second stage of lupine poisoning.

Figure 12. Sheep in third stage of lupine poisoning, in which they usually die.

ment of the animals and to a lack of information regarding conditions under which poisoning almost invariably takes place.

When sheep have been driven hard or shipped or penned they are very hungry. If they are then turned on to a lupine range where the plants are in flower and pods, they will eat the lupine plant as rapidly as possible, especially the pods and seeds, consuming enough of this part of the plant to cause death. Therefore, a rule which should never be violated is, never to turn ravenously hungry sheep on any lupine range, for losses will be almost certain to follow. The most disastrous range losses have taken place where this rule was not observed.

During late summer and early fall the lupines grow abundantly on

many of the sheep ranges. At this time of the year they usually are in full-pod stage and quite frequently the leaves are green and offer the most tempting forage because the other range plants are dry or else have disappeared. It should be remembered that the seeds are by far the most poisonous part of the plant and at this time of the year sheep are very fond of the pods, for they have a pleasant sweet taste that these animals particularly relish. Therefore, a lupine range in the pod stage is dangerous grazing country, especially if the lupines are the most abundant plants on the range.

Whenever it is necessary to drive sheep for any considerable distance over a range infested with lupines it is always highly important, in order to keep losses down, to first allow them to graze with the greatest amount of freedom during the early morning hours. Then, instead of

Figure 13. Sheep poisoned by lupine. Frequently when poisoned they run in no definite direction, butting into bushes, trees, and other objects.

dogging them and trailing them fast, they should be allowed to spread out just as far as possible and to take their time in crossing over the dangerous lupine range.

WATER HEMLOCK

(*Cicuta* Spp.)

The other common names by which this plant is known in Nevada are cowbane, wild parsnip, and poison parsnip.

Description of the Plant.

Water hemlock is a marsh or water-loving plant, tall and branching, from two to six feet high. The smooth, hollow, green stems grow from

a bunch of fleshy, spindle-shaped roots (Figure 14) which have a series of cross-partitions dividing the interior of the root into small, short chambers, as shown in Plate IV which is a typical water-hemlock plant. The leaves are doubly divided, and each leaflet is narrow, long, and finely toothed along the margin. The flowers are borne in dense clusters at the end of the branches and are greenish-white in color.

Plants Commonly Mistaken for Water Hemlock.

The water hemlock is often confused with certain harmless plants which resemble it closely, not only in the appearance of the upper part of the plant, but also in the root structure. When the root of the water hemlock is cut in two lengthwise, it is easy to see the cross-partitions and small chambers. However, there are a few other plants in Nevada which have the same structure in the roots, notably the sweet anise (*Washingtonia*) and the water parsnip (*Sium*).

Sweet anise does not grow in extremely wet places as does the water hemlock; it is found along mountain creek bottoms and in densely shaded places. The anise leaflets are much broader than those of water hemlock and it blooms during the early summer, while the water hemlock does not blossom until midsummer. Sweet anise is not poisonous to stock and is greatly relished.

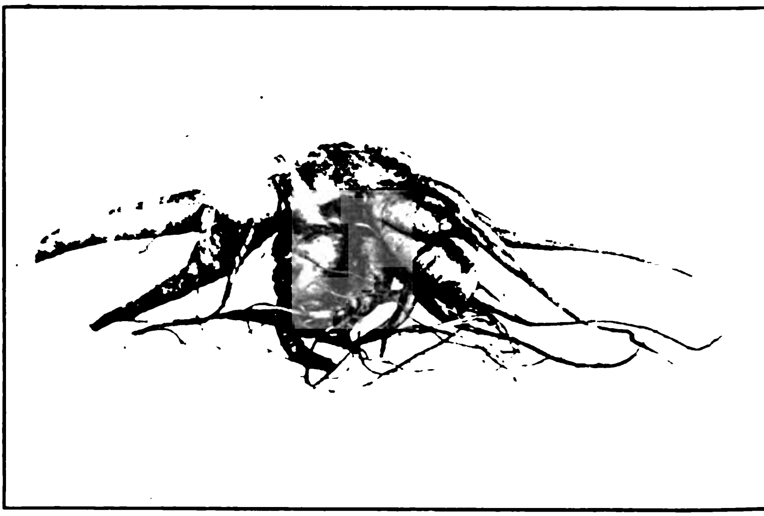


Figure 14. Roots of water hemlock, showing the fleshy, spindle-shaped manner of growth.

The water parsnip grows in wet, marshy places, as does the water hemlock. However, it may be easily distinguished from the water hemlock because the leaves of the water parsnip do not branch, while those of the water hemlock are compound or branching, as is shown in Figure 15.

Distribution and Habitat.

The water hemlock is a typical water-loving plant and as such it is found along the banks of irrigation ditches, streams, in tule swamps, and wild meadow hay land. It has not a wide nor an abundant distri-

Plate IV. WATER HEMLOCK, (Cicuta.)

bution, but where it grows it causes considerable losses each year. It is never found growing away from extremely moist or wet areas.

Animals Which Are Poisoned.

This plant is violently poisonous to all classes of stock. In Nevada very few sheep and horses are poisoned by water hemlock, but there are heavy losses of cattle every year.

Parts of Plant Which are Poisonous.

So far all of the feeding experiments indicate that the only part of the plant poisonous are the roots. The leaves and stems in large quantities have been fed to sheep and cattle with impunity. It is the most poisonous plant which we have on our western ranges, although it does not cause as many losses as some of the other poisonous plants, due to its restricted distribution and the more or less limited possibility of the animal pulling up and eating the root.

Amount Necessary to Cause Death.

It takes only a very small quantity of the root to cause death. Most of the fatal cases reported were caused with two to three ounces in the

Figure 15. A typical water parsnip leaf on the left, and a water hemlock leaf on the right.

case of sheep and eight to twelve ounces with mature cattle. It is therefore readily seen that the roots contain a violent poison.

Symptoms.

It takes from 20 to 40 minutes for the poison to be absorbed after the plant has been eaten so as to cause the first symptoms, which are frothing at the mouth and pronounced uneasiness with extreme pain, more especially in abdominal region. After falling there is convulsive champing of the jaws and gnashing of the teeth, together with violent convulsions, accompanied by a gradual stiffening of the legs with a bending backward of the head and neck. Quite frequently during the period of violent convulsions the animal will bellow and groan from pain. The pupils of the eyes are dilated and the pulse rapid and weak.

The convulsions are intermittent, some prolonged, others of short duration.

The intervals between the muscular spasms or convulsions grow shorter until the animal becomes unconscious and finally dies.

The poison is absorbed and acts very rapidly, and apparently is cast off quite quickly, for the animal fatally poisoned soon dies, while those

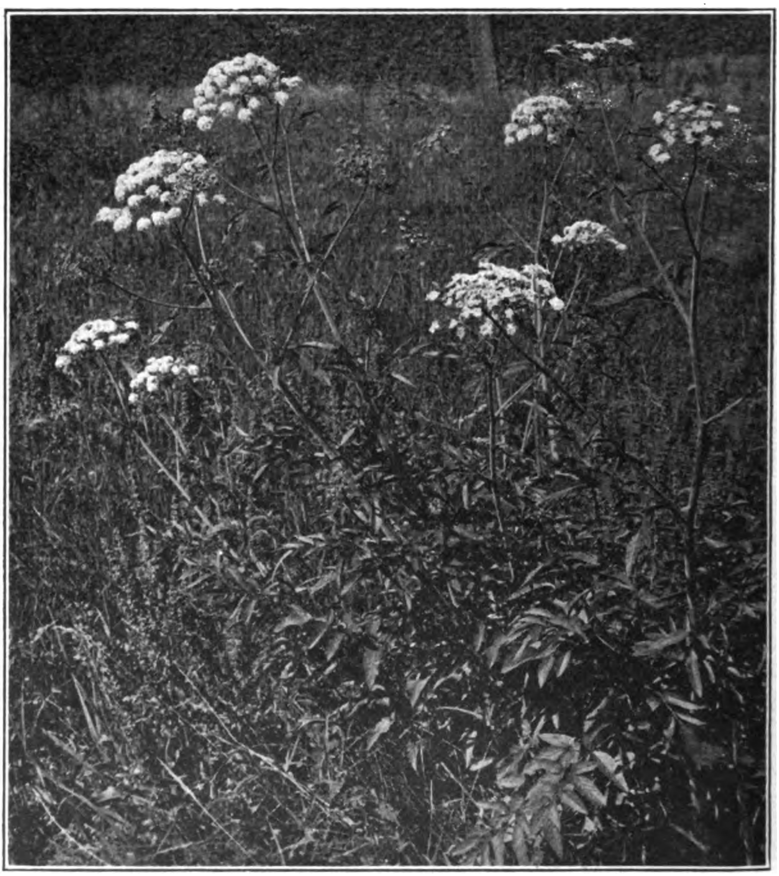


Figure 16. A water hemlock plant showing its typical manner of growth with other vegetation.

which have not eaten a fatal dose soon recover and are, to all outward appearances, well.

Treatment.

At the present time the treatment for water-hemlock poisoning is very unsatisfactory because (1) when an animal eats a fatal dose the poisonous substance contained in the plant is so rapid in its action that death usually results before the animal is found or any treatment can be given; (2) there is no known specific antidote for the poison; and (3) the animal is so excitable when poisoned that to try to give it any treatment in many cases only makes it worse.

Plate V. WESTERN GOLDENROD.

Methods of Handling to Reduce Losses from Water Hemlock.

The water hemlock has such a limited distribution and abundance that it is easily exterminated on ranges where it causes loss, by simply grubbing it out. The cost of one poisoned steer would usually pay for grubbing out all the water hemlock on several acres because of the ease with which it is grubbed and its limited distribution and abundance. (See Figure 16.) After the plant has been grubbed it should not be left on the range or in the field, but it should be put in a wagon and carried off to some inclosure where stock cannot get at it and where it should finally be burned. In case the grubbing was done on the range the most feasible way to dispose of the plant is to dig a hole and throw in the roots. A fire of dry sticks is then built on the roots and when the fire has burned down the hole is filled. Great care should be taken not to leave any of the grubbed roots on the surface of the ground where stock may eat them.

WESTERN GOLDENROD

(*Solidago* Spp.)

The two species which are definitely known to cause loss are found growing in the wild hay lands, in permanent pastures, and well-drained moist mountain country. They are known botanically as *S. spectabilis* and *S. concinna.*

Description of the Plant.

Under certain range conditions the smaller goldenrods seem to be poisonous. A general description of the small goldenrods should therefore be of greater value than a detailed description of any one kind.

The goldenrods which are known to have poisoned sheep are a foot or more high with undivided leaves. The leaves which are close to the ground taper toward the stem; the leaves on the stem are narrow, two to four times as long as broad, and more or less rounded in outline. The leaves produced close to or with the flowers are small, narrow, and flat. The flowers are yellow; they grow in rather dense clusters at the end of the branch stem. Plate V shows the typical form and appearance of the goldenrod which has poisoned many sheep in Nevada.

Where the Goldenrods Grow.

The goldenrods, especially the low-growing varieties, are found all over the northern half of Nevada. They grow in native hay lands, in well-drained pastures, and in the mountain park and meadow country. They do not grow in very dry country with sagebrush, dry grass, and weeds. While they have a wide distribution, they are rarely found growing in any great abundance over a large tract of meadow or pasture lands.

Animals Which Are Poisoned.

So far in Nevada the only animals poisoned by goldenrod have been sheep, among which there have been several disastrous cases of poisoning. Sheep grazing on goldenrod have been poisoned; others died from eating the dry plants in hay.

Parts of the Plant Which are Poisonous.

Only the upper part of the goldenrod is eaten, more especially the

leaves, the flowers, and the younger and more tender stems. The roots of the plant are not pulled up when it is being grazed.

Amount of Goldenrod Necessary to Cause Death.

We do not know just how much goldenrod a sheep must eat before being poisoned. However, animals have died from eating $1^1/_{10}$ pounds of the green plant. Since some sheep have died from eating dried goldenrod in hay and others from pasturing it where there was an abundance of other plants, it seems that only a small amount is necessary to cause serious poisoning or death.

Symptoms.

The first symptoms noted are a salivation or slobbering accompanied by a constant movement of the jaws and lips. There is also continuous quivering of the ears and head, with recurring unnatural contractions of the body muscles. When these contractions take place they appear as if the animal were trying to shake something off the fleece. There is a pronounced arching of the back during these prolonged shaking spells. The legs are usually close together, appearing as though they were tucked up under the body. Any sudden noise will immediately start a shaking of the fleece as above described. The nervous movements or muscular contractions start in the region of the face and head, pass down the neck and back, and finally affect the legs. After being poisoned, many animals, without any cause, will leave the flock, start off in a dazed condition, stepping high with the front legs, with the head held high and quivering. This erect quivering position is held for a minute or more, when a trembling of the muscles of the neck, legs, and back will commence, with a sudden weakness and unsteadiness of gait, when the animal usually falls and passes into a convulsive state. During and immediately after this condition of the animal the pupils are dilated and the sense of direction and distance is completely deranged. As soon as the convulsive motions have ceased there is a champing of the jaws, with salivation, continued shaking of the head, and a quivering movement in the neck. Practically speaking, all animals poisoned seem to have an uncontrollable desire to seize some near-by object, such as a stick or a stone, and to chew it continuously for hours.

Methods of Handling to Reduce Losses from Goldenrod.

Large losses have taken place from feeding goldenrod to sheep in cured hay. If the hay is to be fed to sheep, the areas upon which the goldenrod is found growing should be determined and the hay from these areas stacked by itself and fed to either horses or cattle, which seem to be immune from the poisonous effects of the plant. Usually the loss which occurs as a result of sheep eating goldenrod put up in cured hay is relatively small at any one time, only a few of the animals dying each day. When such losses begin the hay should be examined immediately, and, if found to contain goldenrod, the feeding of it to sheep should be discontinued. Under certain conditions, not yet definitely understood, it seems that hay containing goldenrod may be fed to sheep without any losses taking place. Possibly this is due to the fact that there is such a small amount of the goldenrod scattered through the hay that none of the animals get a sufficient amount of it at any one feeding to cause trouble.

Plate VI. RABBIT BRUSH.

When sheep are pastured where the goldenrod is growing, they should be allowed at all times the greatest possible freedom in the selection of their forage. In order to keep their appetites normal, they should be regularly and abundantly salted. Quite frequently the goldenrod grows in dense patches from which it is entirely practical to herd the animals away. In order to do this the herder must be able to recognize this plant easily and to distinguish it from all others. Plate V is an excellent illustration of the general growth and appearance of the plant. When it is cured in the hay the yellow blossoms will usually still be on the plant, so it is fairly easy to find the goldenrod in case any hay is suspected of causing losses.

Figure 17. Rabbit brush, showing its manner of growth on the range.

RABBIT BRUSH

(*Tetradymia glabrata*)

This shrub is now known to be poisonous at certain times of the year and under certain range conditions. It has already caused the loss of several thousand head of sheep.

Description of the Plant.

It is a rigid shrub from one to four feet high with slender spreading branches which are whitened with matted woolly hairs, which fall off each year. The leaves are smooth and green, the main ones being slender and tapering from a broadened and thickish base to a sharp point, while the young leaves are fleshy and pointless. The flowers are yellow and are borne in clusters. Plate VI shows a typical branch of this shrub, and Figure 17 shows the manner of its growth and branching.

The spiny rabbit brush is very frequently found growing with the rabbit brush above described. It is also a shrub from three to four

feet tall with the branches widely set apart and covered with a dense mat of white hairs. Straight or recurved sharp-pointed spines are produced instead of the primary or main leaves of the ordinary rabbit brush.

Distribution and Habitat.

The rabbit brush has a very wide distribution, being found more or less on all of our dry sagebrush areas. It is in evidence on our dry ranges throughout the year. The characteristic vegetation with which it is found growing is sagebrush, bud sage, white sage (*Eurotia*), shad scale (*Atriplex confectifolia*), salt sage (*Atriplex Nuttallii*), and the green sages (*Chrysothamnus* Spp.). It is also found growing quite frequently in pure stands. It has not been found growing on land full of alkali where the sagebrush is replaced by such shrubs as greasewood (*Sarcobatus* Spp.), and a few of the salt sages, sedges, and rushes. It is never found growing in mountain areas where there is a great profusion of grasses and weeds.

Animals Which Are Poisoned.

Under ordinary range conditions this shrub is very seldom eaten by any class of stock except sheep, and they graze upon it only when forced to do so because of a distinct lack of more desirable forage. Therefore the only animals so far known to be poisoned by it are sheep.

Parts of the Plant Which Are Poisonous.

During the spring of the year this shrub produces many young buds and leaves on which the sheep graze, and consequently it is this part of the plant which has so far been responsible for all the losses. In fact the remainder of the plant is so very woody and tough that it would not be eaten by any class of range stock.

Amount of Rabbit Brush Necessary to Cause Death.

From all observations made so far, before being fatally poisoned a sheep has to graze exclusively on this plant for some time, until the stomach is nearly full. The fresh young leaves and buds with the tender green shoots are the portions eaten, but this occurs only when the sheep are very hungry; for these parts are not highly tempting or pleasing to the taste.

The fresh young leaves and buds contain about 2% of potash, a violent poison, which may be the cause of the death of the sheep. Some sheep can eat far more rabbit brush than others without being poisoned.

Most of the losses which have occurred in Nevada were in flocks which were ravenously hungry or in flocks which had been fed all winter in feed lots and were being trailed over a range where rabbit brush grows. Sheep which have wintered down on the desert where the white sage and the bud sage grow abundantly seem able to eat rabbit brush without being injured. This is probably due to the fact that these sheep have been feeding all winter on plants containing a high per cent of potash or whatever the poisonous substance may be which is responsible for rabbit-brush poisoning.

Symptoms.

After a sheep has filled up on the young green shoots the animal first appears to be very dull and somewhat senseless. It staggers and

is weak. When grazing or standing still it may suddenly fall over in an insensible condition, with the head bent or moved to the side of the body. Muscular spasms follow, the eyes are bulged and staring, the breathing is very shallow. When breathing, the nose and face are wrinkled as though the nose were blocked with some obstruction. Grinding of the teeth is fairly common in all animals down, and after a while bloating takes place. Swelling of the ears and head occurs in many cases. Mucus streaked with blood usually flows from the nose. After the animal falls, death usually follows in from five minutes to an hour.

Treatment.

After a sheep has been poisoned by rabbit brush, little or nothing can be done for it. Usually when a flock is poisoned by eating this plant, large losses take place, and, as there may be several hundred sheep down at the same time, individual treatment is out of the question.

Methods of Handling to Reduce Losses to a Minimum.

Losses may be almost entirely avoided by cautious herding. The most important thing to know is that the sheep are most likely to eat

Figure 18. Sheep grazing on an area supporting rabbit brush. Under these conditions poisoning is likely to occur.

this shrub when they are exceedingly hungry or when there is a scarcity of other range forage. (See Figure 18.) The herder should become thoroughly familiar with the appearance of rabbit brush, and when he sees that the animals are feeding almost exclusively on the green tender parts he should, if possible, remove them immediately to a range free from it. He should be able to recognize this poisonous brush at a glance, and should drive the sheep where it does not grow. This knowledge is particularly desirable when the sheep are on the trail or at feeding-places along the railroads, at shearing corrals, or when they have been shipped long distances and are extremely hungry.

When in this condition they eat everything that is not positively objectionable, and as a result, if the rabbit brush is present, they will eat enough of it to cause death. Ordinarily they do not eat enough to do them any harm.

Often, when sheep are moved from the winter feeding-grounds to their spring and summer ranges, flock after flock will be driven over the same driveways, along roads or narrow lanes. These driveways are usually overgrazed and at their best contain but little good feed. The first flocks going over eat out all the most palatable plants, leaving only the less desirable ones. The flocks that follow are forced to eat such plants and shrubs as death camas and rabbit brush, with disastrous results. Therefore, in moving sheep from one range to another, it is best not to allow one flock to follow another if the rabbit brush is the only feed left.

When sheep have been shipped long distances they are exceedingly hungry. Before starting to graze them on a strange range or on a range known to be infested with any poisonous plants, it is always much cheaper to fill them up on hay before moving them from the railroad point. Usually around loading corrals and shearing plants the range is overgrazed, a condition which favors the greatest losses from poisonous plants, especially rabbit brush.

LOCO

(*Aragallus* Spp. and *Astragalus* Spp.)

The almost universal name by which these plants are known on the western ranges is "Loco," from the Spanish word meaning crazy. They are therefore sometimes called crazy weed, from their effect on all classes of range animals.

Description of the Plant.

There are many different species of loco in Nevada, none of which cause serious losses. The locos belong to the pea family and have typical pea-blossom flowers borne in a crowded arrangement near the end of the flower stem. The flowers are of various shades of purple, yellow, white, or red. From them a pea-like pod is formed, often inflated or bladder-like in appearance, containing from two to many small seeds. The leaves have a very peculiar and characteristic appearance by which the plant may be readily distinguished on the range. They are made up of many small leaflets attached on each side of one leaf stem with an odd leaf always formed at the end, as shown in Figure 19.

Distribution and Habitat.

The locos are very widely distributed all over Nevada, being found on practically all grazing types such as the weed areas, sagebrush, open park, sand grass, white sage, and semidesert ranges. They are found at all elevations.

Animals Which Are Poisoned.

All classes of range animals are affected by these plants. However, sheep and horses are more likely to become locoed than are cattle.

There is only a small number of locoed animals in Nevada. The

main losses occur in the extreme southern part of the State, where but few cattle, sheep, and horses are ranged on account of the lack of water and feed.

Symptoms.

There are two ways in which the loco plant may affect range animals; (1) acute poisoning, killing them within a few days, and (2) slow poisoning, where the animals live for a considerable length of time, from six months to a year or more, during which time they show the same symptoms as in the acute form, only to a milder degree.

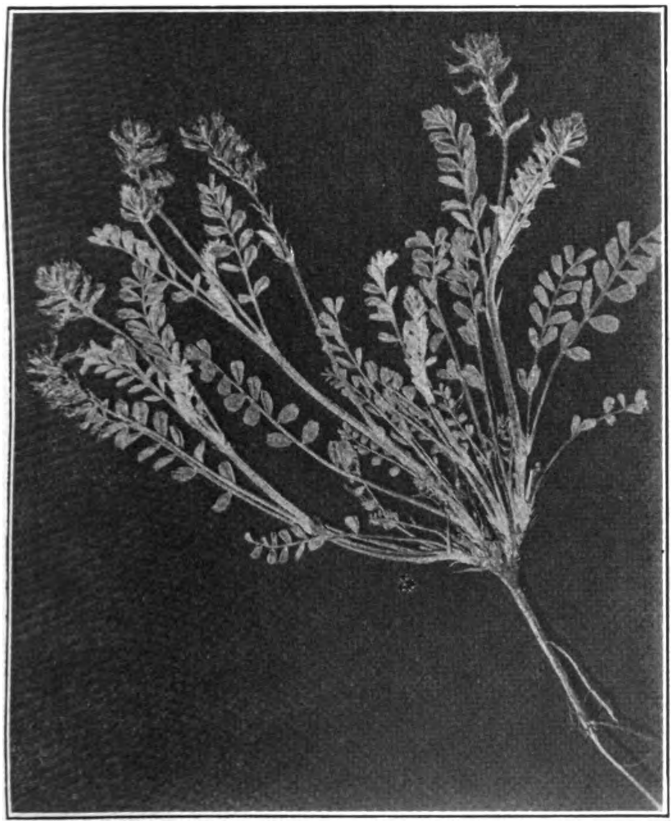


Figure 19. A loco plant, showing manner of growth and arrangement or leaflets on axis of leaf.

The most typical characteristic symptom of the locoed animal is the lack of muscular control when walking, the gait being like that of a drunken man. The animal's sight is impaired, and it cannot judge the size and distance of objects accurately. In serious cases total blindness occurs and the sense of hearing is frequently affected, often to such an extent that the animal is unable to determine the direction from which a sound comes. In cattle and horses the head is usually carried low, the coat becomes very rough, and the gait staggering

and slow. Frequently with sheep a general shedding of the wool takes place or it is shed only in patches. The back is quite frequently extremely arched, and there is trembling, especially of the legs and knees. It is almost impossible to keep a bunch of locoed sheep from

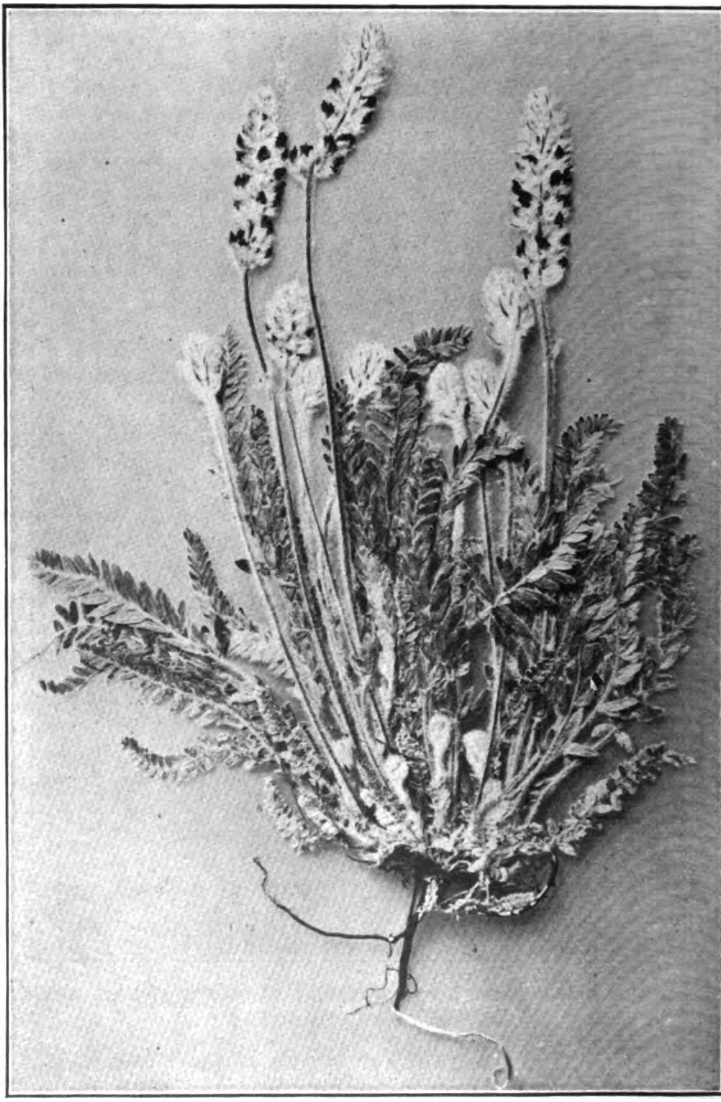


Figure 20. A loco plant, showing the hairy growth all over the plant. All locos producing this hairy growth may be looked upon with suspicion.

straying or to drive them in any definite direction. With many animals the sight becomes so badly affected that they cannot keep up with the flock, and they are often found dead in deep ravines, or drowned in

streams or water holes. As a result of feeding almost exclusively on loco the animal finally dies of exhaustion and starvation. In the later stages the locoed horse becomes very poor, his eyes are sunken, and he usually is abandoned by both man and beast, and will stand for days and even weeks upon a very small area of ground without water and with very little food until death from starvation relieves him.

Methods of Handling to Reduce Losses from Loco.

The loco weeds capable of causing the typical symptoms are highly unpalatable and are very rarely touched by any animal except those which are extremely hungry or which are grazing on a range where there is a distinct lack of more desirable plants. This is the case on all overgrazed ranges or where, due to climatic conditions, the loco weed is the predominating plant. Under these conditions the animals are forced to eat the loco. After having once developed an appetite for it however, they graze it in preference to all other range plants. When stock are grazing upon an area infested with loco a very close watch should be kept, and as soon as any of them commence to show signs of being locoed they should be immediately separated from the rest and placed in an inclosure and fattened. If this is not possible, they should be taken to a range free from loco.

If the animal has become rather poor, as is always the case after it has been eating the plant for some time, it should be given a very nutritious ration and for a few days 4 ounces of magnesium sulphate should be dissolved in the drinking water. In case of horses which are extremely nervous Fowler's solution should be given for from two weeks to a month in daily doses of 4 drams either in the drinking water or the grain.

Animals develop the loco habit primarily as a result of a lack of palatable nutritious range forage. After an animal has once acquired the taste for loco it must never again be turned on a range where the loco is found growing. In order to reduce the chances of sheep developing a taste for the plant, they should be grazed in open formation, which will allow natural freedom in the selection of their forage and they should be allowed to bed down wherever they are on the range at night. (See Figure 21.) When sheep are bedded for several nights on the same bed-ground they first graze out all of the most desirable plants, and such weeds as the locos are left until the last. If the use of the same bed-ground is continued after all the valuable plants have been removed, then these animals will be forced to eat the loco with a very good chance of developing the loco appetite. Further, when a sheep is hungry it is not particular about what it eats. Therefore, all flocks should be allowed to leave the bed-ground just as early as possible in the morning, for the longer they are kept from grazing the more hungry they become and the chances for their grazing the loco correspondingly increase. Ewes with lambs should at all times be allowed to graze openly and quietly because lambs are more likely to develop the loco habit than are the old ewes. If the lambs are separated for any length of time from their mothers, due to close herding, running and massing, they become very hungry with the increased possibility that while in this hungry condition they will eat the loco weed. Salt should always be supplied, so that the animals will not develop a perverted taste.

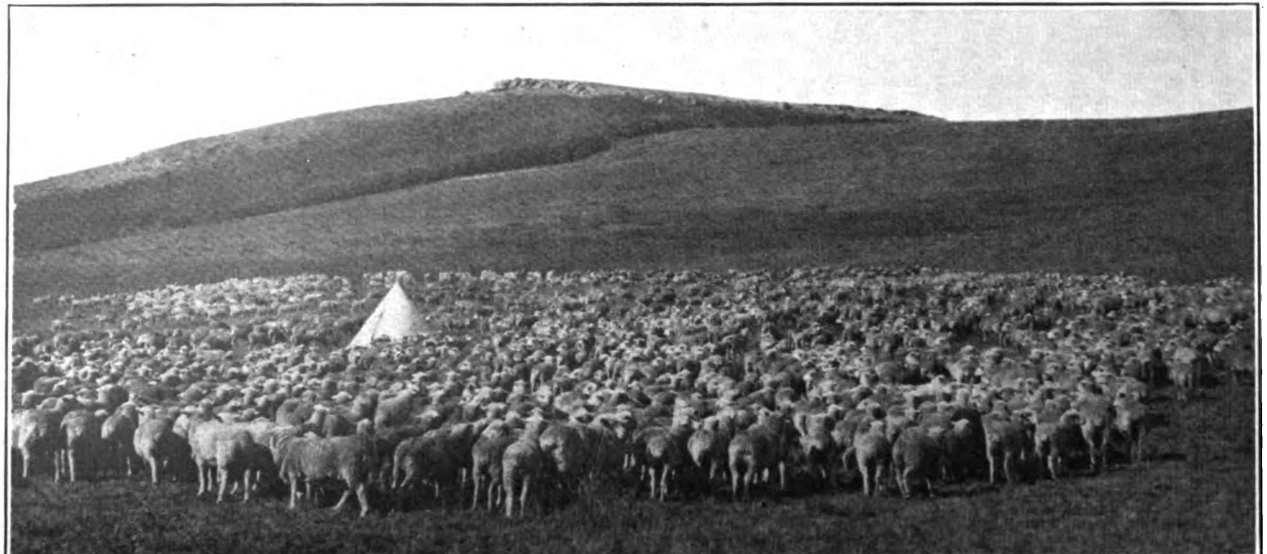


Figure 21. Sheep ready to bed down at evening on a new bed-ground. If the bed-ground is changed daily sheep are less liable to graze poisonous plants with fatal results.

Thus, in order to keep the number of locoed animals down to a minimum, they should be grazed openly, with little running or massing taking place, should be permitted if possible to choose their own bed-ground, should be supplied with a regular and liberal amount of salt, and allowed to graze during the early morning and evening hours, on range where there is an abundance and variety of good forage plants.

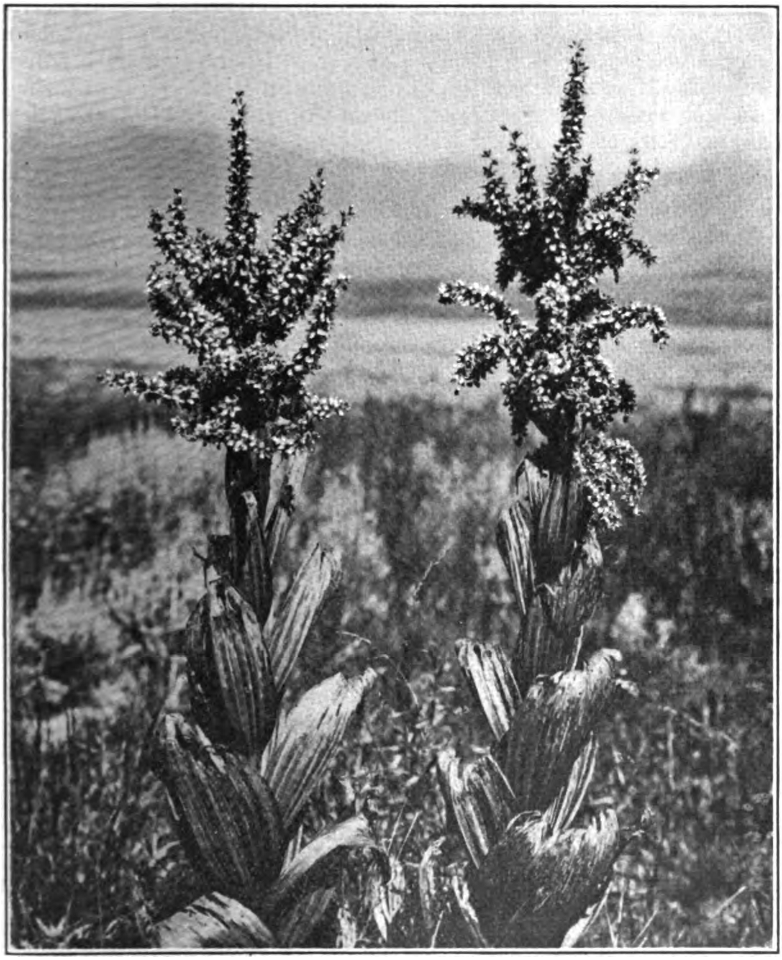


Figure 22. False hellebore, showing the manner of its growth and the shape of its leaves and flowers.

FALSE HELLEBORE

(*Veratrum* Spp.)

The common names by which this plant is known on the range are cow cabbage, wild Indian corn, Indian poke, poke root, bear corn, and swamp hellebore.

Description of the Plant.

A tall plant, growing from two to six feet high; thick, short rootstocks; leaves broad, clasping, prominently veined and plaited. The stems and flowers are covered with a fine growth of hairs; the flowers are a greenish-yellow or greenish-white in color.

Distribution and Habitat.

This plant is not widely nor abundantly distributed in Nevada. However, it is found quite frequently in certain mountain country where the soil is of a rich loamy nature and is supplied with a liberal amount of water. Thus it is found in swampy places, along streams and in wet meadows. Figure 22 shows the manner of its growth and the shape of its leaves and flowers.

Animals Which Are Poisoned.

In Nevada the only animals known to be poisoned by eating false hellebore are sheep. Cattle have been observed to eat the leaves with no ill effects after they have been frosted and turned reddish-brown in the fall of the year.

Many lambs have been poisoned because they ate the large buds and crowns just as they were commencing to grow in the spring. Many cases of poisoning have been observed on closely grazed ranges where the sheep filled up on the false hellebore almost exclusively, after which practically all the sheep in the flock became sick and several died.

Symptoms.

The first symptoms noted are extreme salivation accompanied by vomiting or attempts to vomit. With many animals there is a pronounced muscular weakness, muscular tremors, spasms, and general paralysis. The breathing in all animals which are too weak to be able to stand is shallow, the temperature is materially reduced, the skin is cold, the sight impaired, and death results from what may be called suffocation.

Methods of Handling to Reduce Losses from False Hellebore.

With the exception of lambs but very few sheep are fatally poisoned from eating the false hellebore. However, each season many sheep are made violently sick because they fill up exclusively on this plant. When it is eaten in moderate amounts it causes no ill effects, but when animals are allowed to fill completely on it, then poisoning takes place. In order to avoid this, care should be taken to allow the animals to eat it only moderately or else not at all.

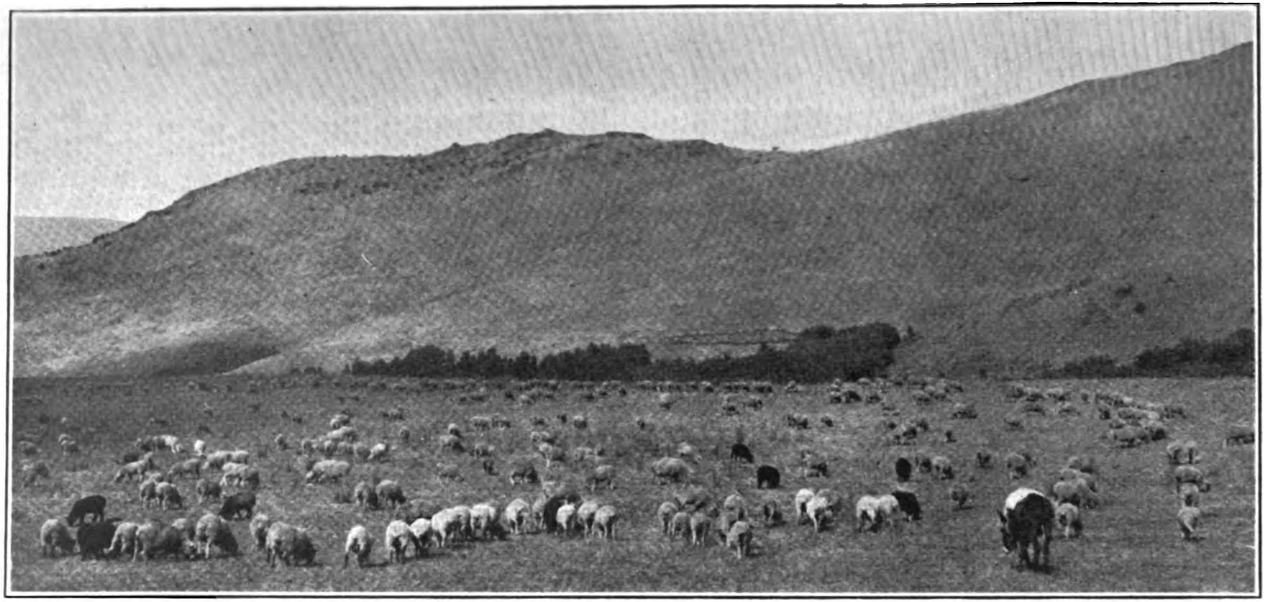


Figure 23. To reduce losses from poisonous plants sheep should be allowed to graze openly and quietly, to give them the greatest possible chance to select their range feed.

ACKNOWLEDGMENT

The translation into Spanish of the foregoing bulletin, which is printed on the following pages, was made by Benjamin Franklin Schappelle, Assistant Professor of the Romanic Languages and Literatures, University of Nevada. The Experiment Station herewith tenders Professor Schappelle its gratitude for his services.

PLANTAS VENENOSAS A OVEJAS Y A GANADO EN LOS RANCHOS DE NEVADA

ESPUELA DE CABALLERO O CONSÓLIDA REAL. (LARKSPUR.)

Dos géneros de consólida real crecen en los ranchos de Nevada. Se conocen como consólida real alta y consólida real pequeña, nombres comunes basados en la altura de la planta.

Las consólidas real altas son plantas erguidas y ramificadas de dos a seis pies de altura, las raíces son grandes, hondas y bastante leñosas, con una o más copas de que se generan los tallos. La forma de la hoja se ve en figura 1. Las flores son de varios tintes de azul o púrpura y tienen una forma distintiva a causa de la estructura puntiaguda del sépalo superior indicado en figura 2.

La consólida real pequeña genera generalmente un solo tallo de 9 a 12 pulgadas de altura. Esta planta está indicada en placa I.

Plantas comunmente tomadas por consólida real.

Las dos plantas comunmente tomadas por consólida real son el geranio silvestre color de rosa (wild pink geranium) y el acónito (aconite).

En la primavera las hojas del geranio silvestre se asemejan mucho a la consólida real a causa de los dos pequeños y puntiagudos apéndices indicados en figura 2 que no se encuentran en el pecíolo de la consólida real. Si se apreta la hoja del geranio el aroma característico del geranio resulta. La hoja de la consólida real no tiene este aroma. La hoja del geranio está generalmente cubierta de un crecimiento de vello pequeño, fino y pardusco, mientras que las hojas de la consólida real son cubiertas de una copa blanca de superficie borrable, muy parecida a la de ciruelas y de uvas.

El acónito se diferencia de la consólida real en que las hojas superiores del acónito son mucho más numerosas y casi no tienen vástagos. Las flores, en vez de ser puntiagudas como las de la consólida real, son cubiertas con una caperuceta como se ve en figura 2. Esto le da el nombre Inglés común de "monkshood."

Distribución y regiones donde crece la consólida real.

La consólida real se encuentra en casi cada rancho de la mitad septentrional de Nevada. Crece en lugares bien desaguados, húmedos y margosos; a lo largo de los lechos de riachuelos; en los campos abiertos de las montañas; y sombreado en parte por grupos de alisos y tiemblos.

La consólida real pequeña crece en suelos bien desaguados pero no demasiadamente húmedos y generalmente a plena luz del sol. Así, los cerros de las montañas y los ranchos de artemisia fronterizos son los dos lugares típicos donde la consólida real pequeña más abunda.

Animales que se envenenan por consólida real.

En las condiciones comunes de los ranchos sólo el ganado se envenena por la consólida real.

Partes venenosas de la planta.

Las plantas de consólida real alta que son la causa de la mayor parte

de las pérdidas son bien arraigadas, y cuando los animales se las apacentan, es casi una imposibilidad física que las raíces se desarraigen con la planta. Por consiguiente, se comen sólo las partes superiores y verdes.

Pruebas de alimentación indican que el veneno no se encuentra en las raíces pero en la parte superior de la planta. Las semillas forman la parte más venenosa, después las hojas, y ultimamente los tallos. Después de que la planta ha florecido el veneno desaparece de los tallos y de las hojas y se concentra en las semillas. De eso resulta que el ganado puede comer las hojas y los tallos de la consólida real después de que ha florecido y producido las semillas.

Cantidad de consólida real precisa para matar.

La consólida real es más venenosa durante su desarrollo temprano de Abril, Mayo y Junio. En cuanto que envejece se vuelve menos venenosa y para matar necesita mucho más de la planta que durante el primer período de desarrollo. Después de que la consólida real alta ha florecido, pierde su calidad venenosa y el ganado puede comerla sin gran peligro de hacerse daño. Pruebas de alimentación demuestran que necesita de consólida real 2½ a 3 por ciento del peso del animal para matarlo.

Síntomas de envenenamiento por consólida real.

En los terrenos de pasto la caída del animal es el primer síntoma que se observa y si el envenenamiento ha sido grave el animal no puede ponerse en pie otra vez y muere. Pero, la mayor parte de los animales, después de caer por primera vez, se ponen en pie y andan con las piernas traseras muy apartadas. Tambalean más o menos y hay poco o no movimiento en las articulaciones de las piernas. Cuando cae el animal, lo hace de una manera típica; en general las piernas delanteras se aflojan primeramente, entonces el animal se sostiene en que apoya la barba o el lado de la cabeza en el suelo. En los casos muy graves el animal se reposa tendido en el suelo y alza la cabeza de cuando en cuando, mientras que en los casos menos graves sostiene la cabeza erguida. Cuando está de pie se verifica un temblor por todo el cuerpo del animal, especialmente alrededor de la nariz y de la boca. Estas contracciones de los músculos se nota también alrededor de los hombros, de las caderas y de los costados. Con frecuencia hay un eructo de gas y un esfuerzo por el animal para vomitar. Hay un babear o babosear considerable. Casi invariablemente hay constipación.

Método curativo.

Después de que el animal ha caído no debe ser perturbado a menos que no yace en suelo barrancoso. En este caso hay que poner la cabeza más alto que el cuerpo para dejar respirar más facilmente al animal. El método de tratamiento común de sangrar el animal no debe ser empleado. Si el animal tienta de vomitar se puede concluir que ha tomado una dosis fatal y no se puede hacer nada para salvarlo. Generalmente hay buena esperanza de recuperación si se deja yacer el animal tan quieto que posible y se le da el tratamiento siguiente:

"Physostigmin salicylate" ....1 gramo,
"Pilocarpin hydrochlorid" ....2 gramos,
"Strychnine sulphate"............................½ gramo.

Se administra esto de la misma manera que el vacunar contra morriña negra (blackleg). Se emplea una jeringa hipodérmica de 4 dracmas en la operación. Es preferible disolver la tableta en agua clara y limpia y, si es posible, hervida. No se repite la dosis.

Métodos de manejo de ganadería para reducir las pérdidas por consólida real.

Cuando se encuentra la consólida real en pedazos de terreno bien marcados, el método más sencillo para prevenir pérdidas es bien desherbar. Se deshierba la planta al menos 6 pulgadas debajo de la superficie del suelo. El precio medio para eso no debe superar 5 a 8 duros por acre.

En algunos ranchos es practicable primeramente dejar las ovejas pastar en los terrenos de consólida real hasta que la vitalidad de las plantas es muy reducida. Mientras tanto se reserva los terrenos no infestados para el ganado.

En todos los ranchos se debe siempre proveer sal liberalmente. Donde hay consólida real es preferible establecer terrenos de saladura a bastante distancia de los terrenos infestados por las plantas venenosas. Así el ganado no se congrega donde la consólida real abunda.

Es preciso nunca conducir ganado muy hambriento por terrenos de consólida real. Mientras que el estómago está vacío los animales comen muchas plantas que generalmente no tocan; y como la consólida real no es una planta sabrosa el riesgo de pérdidas es muy aumentado cuando los animales están hambrientos.

DEATH CAMAS. (ZYGADENUS.)

Los otros nombres comunes aplicados a "death camas" en los ranchos de Nevada son "poison wild onion," "poison sego," "poison camas," "mystery grass" y "lobelia." Sin embargo, "death camas" es el nombre más común y el que se debe emplear.

Descripción de la planta.

"Death camas" es una planta erguida que genera 5 a 7 hojas formadas como hierba gruesa. Crece de un bulbo de tongas puesto de 2½ a 6 pulgadas en el suelo. Este bulbo es de ½ a 1¼ pulgadas de espesor y es cubierto de envolturas finas parecidas a papel como se ve en figura 4. Las hojas son de 6 a 18 pulgadas de largo por un poco menos de media pulgada de ancho y tienen semejanza a hierba con lomo proyectante como una quilla de barco en el lado inferior. Tienen mucho más jugo y son más espesas que las hojas de hierba comunes. No hay tallo bien marcado y las hojas aparecen como si viniesen de la superficie del suelo. Las flores son de color amarillo-verdusco o blanco, de cuarta pulgada más o menos de ancho y producen un racimo de flores que es de 3 a 10 pulgadas de largo. En placa II se ve la apariencia típica de "death camas."

Plantas frecuentemente tomadas por "death camas."

Se confusa el "death camas" comunmente con la cebolla silvestre (wild onion). El bulbo y las hojas de "death camas" no tienen, sin embargo, el aroma de la cebolla silvestre y todas las flores de ésta crecen de una sola punta en la extremidad del pedúnculo, mientras que las flores de "death camas" se generan al lado del pedúnculo como se ve en figura 6.

Distribución y regiones donde crece el "death camas."

El "death camas" se encuentra en casi todos los ranchos de Nevada y los terrenos en que florece son invariablemente húmedos durante la primavera. Los lugares principales en que se lo encuentra son: (1) de artemisia, (2) de hierba, (3) prados y (4) terrenos típicos de mala hierba donde la vegetación consiste en plantas vistosas que producen flores. Se lo encuentra en los ranchos a mediados de Marzo y al fin de Junio ha muerto generalmente y el peligro de la planta ha desaparecido.

Animales que se envenenan.

Esta planta es venenosa a todas clases de ganado y especialmente a ovejas. Los caballos comen raramente bastante para causar muerte pero a veces hay pérdidas de vacuno cuando éste pasa en condición hambrienta por el rancho.

Partes venenosas de la planta.

Todas partes de la planta son venenosas pero comunmente los animales comen las flores y las hojas mientras que el bulbo está muy hondo en el suelo y rara vez se lo arrancan.

Cantidad necesaria para matar.

Un animal muy hambriento se envenena fácilmente. En el rancho una oveja de un peso de 100 libras más o menos tiene que comer de 1½ a 5 libras de la planta para envenenarse; para matar un cordero necesita proporcionalmente menos.

Síntomas de envenenamiento por "death camas."

Cuando una oveja se envenena por "death camas" el primer síntoma que se nota es que la andadura del animal es muy rígida, especialmente la de las piernas traseras. Cuando el animal cae lo hace comunmente con la cabeza antes, las piernas delanteras siendo más débiles que las traseras.

En casos muy graves el animal yace tendido en el suelo con respiración lenta y fatigosa. De repente respira muy rápidamente para un rato después de que vuelve a respirar lentamente. Con frecuencia hay un babosear de la boca con un molimiento de los dientes. El paladar es de color azulado. Casi invariablemente los animales envenenados vomitan. Se ha notado muchas veces que los animales tendidos en el suelo y respirando fatigosamente de repente dan fuertes puntapiés, tuercen el cuerpo y agitan la cabeza como si fuesen en agonía. Algunos mueren así pero la mayor parte entran en un estado de insensibilidad profunda de que no se puede despertarlos y así mueren.

Medios preventivos.

Las ovejas muestran gran cuidado en el escogimiento del forraje mientras que pastan tranquilamente en los ranchos. Pero mientras que se las conduce de un lugar a otro no pueden escoger el forraje y así comen todo lo que no es enteramente contra su gusto. Entonces, si hay "death camas" se lo comen en cantidades más grandes que de las que pueden descartar y de resultas mueren. Así, para evitar pérdidas es preciso tratar las ovejas de manera que nunca estén muy hambrientas. Si se las conduce de un terreno de pasto a otro hay que dejarlas tan tranquilo que posible durante una hora o dos por la

manaña antes de moverlas. Después de eso escogerán su forraje con cuidado de resultas que las pérdidas serán muy reducidas.

Para impedir pérdidas es muy preciso conducir las ovejas tan temprano que posible de los terrenos donde duermen porque más tiempo que tienen que quedarse en estes terrenos, más hambrientas estarán. Así tendrán menos cuidado en lo que comen en los terrenos de pasto.

El medio general de manejar ovejas, especialmente durante la primavera, consiste en establecer un campamento permanente a que se las conduce todas las noches hasta que todo el forraje en los terrenos alrededor del campamento ha desaparacido de un radio de 2 o 3 millas. De eso resulta que las ovejas comen todas las plantas, las venenosas antes y las no venenosas después de resultas que habrá pérdidas. En vez de este medio incorrecto de manejar, sería mejor dejar las ovejas acostarse por donde se hallen por ventura al anochecer. Así encontrarán forraje fresco al amenecer y los casos de envenenamiento serán muy reducidos.

Si una oveja no ha recibido sal durante una semana o diez días desarrolla un apetito anormal y come plantas que regularmente no tocaría. Así es preciso siempre proveer media onza de sal para cada oveja o una libra más o menos diariamente para cada treintena de animales.

ALTRAMUZ O LUPINO. (LUPINES.)

Los lupinos se conocen en Nevada bajo varios nombres comunes. Se los llama incorrectamente "blue bean," "wild bean," "wild alfalfa," y "blue pea."

Descripción.

El lupino apartenece a la familia de guisantes y es una planta erguida de 6 pulgadas a 3 pies de alto. La mayor parte de las especies de Nevada crecen de año en año de las mismas grandes raíces hondamente colocadas. Estas raíces generan varios tallos, las hojas de los cuales tienen pedúnculos largos. Hay 4 a 15 divisiones de hojas pequeñas, todas creciendo del ramal común como se ve en figura 8. Las flores son sostenidas en macollas largas y tienen una forma como las del guisante. Son de varios tintes de azul, blanco, rosado y amarillo. Las vainas contienen una o más semillas y generalmente son cubiertas de un crecimiento espeso de vello corto y fino. Este vello se encuentra en la superficie superior de las hojas, dando a la planta una apariencia pardusca. El lupino florece del principio de la primavera hasta el fin del otoño. Genera la mayor parte de las flores y de las vainas durante los meses de Julio y Agosto. En placa III se ve la apariencia típica del lupino.

Distribución y regiones donde crece el lupino.

El lupino es una de las plantas más copiosamente distribuidas en los ranchos de Nevada. Se lo encuentra en todas las elevaciones bajas y en todos los típos de suelo con excepción de los que son excesivamente húmedos o aridos o los qué tienen demasiado álcali.

Animales que se envenenan.

En ciertas condiciones de los ranchos los lupinos pueden ser venenosos a todas clases de ganado. Las pérdidas principales resultan, sin embargo, cuando las ovejas comen el lupino después de que las semillas se han formado en las vainas. En el otoño cuando el otro

forraje escasea y lo que se queda es seco el lupino aun florece. Entonces las ovejas se lo comen y de resultas se envenenan. Cuando el lupino tiene semillas en las vainas es preciso no dejar las ovejas pastar en el terreno donde se lo encuentra a no ser que hay otras plantas que prefieran. Sin embargo, por todo el estado de Nevada hay un insecto pequeño que vive en las vainas del lupino y se alimenta de las semillas. Entonces las vainas aparecen como si contuviesen semillas, pero, examinandolas bien se ve que no las tienen y por eso no son venenosas.

Partes venenosas de la planta.

La mayor parte de las pérdidas son causadas por las vainas y por las semillas. En ciertas condiciones de los ranchos todavía no bien determinadas las hojas y las partes superiores de las plantas a veces causan pérdidas.

Cantidad necesaria para matar.

La cantidad que un animal tiene que comer para envenenarse es muy variable. Pruebas de alimentación muestran que para una oveja de cien libras de peso necesita $\frac{1}{4}$ a $\frac{1}{2}$ libra de semillas sólo y aproximadamente $1\frac{1}{2}$ libras de vainas y semillas juntas para matar.

Síntomas de envenenamiento por lupino.

El síntoma más común de envenenamiento por esta planta se ve en la manera de que respira el animal. En casos agudos o severos respira con gran dificultad. Durante estos períodos de respiración difícil el animal se tuerce violentemente y con gran excitación mental o corre en dirección indefinida, topezando con otros animales del rebaño o con cualquier obstáculo que encuentra en su paso, tal que morral, árboles o rocas. Acompañando la respiración difícil generalmente hay un babosear de la voca y el paladar es comunmente de color azul. Muchos animales mueren en un estado de espasmos violentes.. Otros entran en un sueño profundo de que no se despiertan.

En casos menos agudos la respiración es fatigosa y las ovejas se quedan de pie o reposen en un sueño profundo. Otro síntoma típico consiste en que las orejas se inclinan y la oveja topeta otros animales o obstáculos con la cabeza. Después de que el animal ha pasado el período de respiración fatigosa se queda temblante por todo el cuerpo. Figuras 10, 11, 12, 13 muestran el ademán típico de ovejas envenenadas por lupino.

Método de manejar ovejas para evitar pérdidas.

Si se conduce ovejas que están en estado hambriento por terrenos donde florece el lupino, ellas comerán rápidamente las plantas, en particular las vainas y las semillas, en cantidades suficientes para matar. Por esta razón es preciso nunca conducir ovejas en estado hambriento por terrenos donde se sabe que florece cualquier planta venenosa. Cuando es necesario conducir ovejas una distancia considerable por terrenos infestados por lupino es muy importante dejarlas pastar antes tranquilamente durante las primeras horas del día. Después, en vez de moverlas rápidamente con perros, hay que dejarlas esparcirse tanto que posible y pasar así por los terrenos peligrosos.

CICUTA. (WATER HEMLOCK.)

Otros nombres comunes para esta planta son "cowbane," "chirivía silvestre" (wild parsnip), y "chirivía venenosa" (poison parsnip).

Descripción.

La cicuta es una planta que florece en pantanos. Es de 2 a 6 pies de altura. Se ramifica con lisos vástagos huecos de color verde creciendo de una macolla de raíces gruesas y ahusadas (figura 14) que tienen una serie de particiones cruzadas partiendo el interior de la raíz en cámaras pequeñas como se ve en placa IV. Esta placa muestra una cicuta típica. Las hojas son doblemente divididas y cada hojilla es estrecha y finamente dentada por lo largo del borde. Genera flores blanco-verdosas en macollas compactas en las extremidades de las ramas.

Plantas comunmente tomadas por cicuta.

Cuando se corta la raíz de la cicuta longitudinalmente se ve las particiones cruzadas y las cámaras pequeñas ya mencionadas. Sin embargo, hay otras plantas que tienen la misma estructura de la raíz, notablemente el anís dulce (sweet anis) y la berraza (water parsnip). El anís dulce no florece en suelos muy húmedos pero se lo encuentra a lo largo de los lechos de riachuelos de la montaña y en lugares tranquilos y bien sombreados. Las hojillas del anís son mucho más anchas que las de la cicuta. El anís florece durante la primera parte del verano mientras que la cicuta no florece antes de pleno verano. El anís es muy sabroso y no envenena el ganado.

La berraza crece en lugares húmedos como la cicuta. Pero, se puede facilmente distinguir ésta de aquélla en que las hojas de la berraza no se ramifican mientras que las de la cicuta son divididas o ramificadas como se ve en figura 15.

Distribución y terrenos donde florece la cicuta.

La cicuta es una planta que florece en lugares muy húmedos como por lo largo de las orillas de zanjas de regadura y de riachuelos, en pantanos de espadaña (tule) y en prados silvestres de heno. No tiene gran esparcimiento. No se la encuentra nunca afuera de terrenos muy húmedos.

Animales que se envenenan.

La planta es muy venenosa para todas clases de ganado. En Nevada la mayor parte de las pérdidas consiste en ganado vacuno. Raramente hay pérdidas de caballos ú ovejas.

Partes venenosas de la planta.

Todas partes de la planta son venenosas pero las raíces lo son mucho más que las verdes partes superiores.

Cantidad de raíz de cicuta necesaria para matar.

Necesita sólo una porción pequeña de la raíz de la planta para matar. La mayor parte de los casos graves relatados eran causadas por una porción de la raíz de grandor de un huevo de gallina o menos.

Síntomas de envenenamiento por cicuta.

Los primeros síntomas son: (1) contracción nerviosa de los músculos de la boca y de las orejas; (2) generalmente náusea y vómito en los casos de ganado vacuno y de ovejas; (3) un babosear cuantiosa de la boca y un temblor por todo el cuerpo; y (4) espasmos violentos con un atiesar de las piernas y un encorvar hacia atrás de la cabeza y del

cuello. Los intervalos entre los espasmos disminuyen hasta que el animal se queda insensible y al fin muere.

Remedios.

No se ha encontrado todavía un remedio satisfactorio y eficaz contra envenenamiento por cicuta. Es preciso perturbar el animal tan poco que posible para aumentar la suerte de su recuperación.

Métodos de manejo para disminuir pérdidas por cicuta.

La cicuta tiene tan poca distribución y abundancia que es muy fácil exterminarla en los ranchos donde causa pérdidas en que se deshierba la planta y las raíces y las quema o las entierra hondamente. En los terrenos de pasto es muy fácil reunir las ovejas afuera de los lugares donde crece la cicuta cuando el pastor conoce la apariencia de la planta.

WESTERN GOLDENROD. (SOLIDAGO.)

Hay dos especies de "goldenrod" que causan pérdidas en Nevada. Todos crecen en terrenos de heno silvestre, en dehesas permanentes y en campos abiertos y bien desaguados de las montañas.

Descripción.

Los "goldenrods" que causan pérdidas son de un pie o más de altura y tienen hojas indivisas. Alrededor de la base de la planta las hojas se adelgazan hacia el tallo. Las hojas que se generan en el tallo son angostas, dos a cuatro veces más largo que ancho y redondeadas más o menos en perfil. Las hojas que se generan cerca de o juntas a las flores son pequeñas, angostas y llanas. Les flores son amarillas y crecen en macollas espesas al cabo de un vástago ramificado. Placa V muestra la apariencia típica del "goldenrod." Es esta especie de la planta que ha causado muchas pérdidas en Nevada.

Distribución y terrenos donde crece el "goldenrod."

En Nevada el "goldenrod" crece en terrenos de heno nativos, en terrenos de pasto bien desaguados y en campos abiertos y prados de las montañas. No se lo encuentra en terrenos áridos de artemisia o por donde crecen el herbajo y la hierba seca.

Animales que se envenenan.

Hasta ahora las pérdidas notadas consisten sólo en ovejas que habían comido esta planta en terrenos de pasto o mezclada con heno.

Partes venenosas de la planta.

Los animales comen sólo la parte superior de la planta, especialmente las hojas, las flores y los tallos tiernos.

Cantidad de "goldenrod" necesaria para matar.

Algunas ovejas se han envenenado en que habían comido 1.1 libras de la planta verde. Otras pérdidas han resultado de que los animales habían pastado en la planta que era mezclada con heno o la habían comido en terrenos de pasto donde había una abundancia de otras plantas. Eso prueba que la planta es muy venenosa y que sólo una cantidad pequeña es necesaria para matar.

Síntomas.

Los síntomas primeros consisten en salivación o babosear acompañado con un movimiento continuo de las mandíbulas y de los labios. Hay también un movimiento continuo de las orejas y de la cabeza con una contracción recurrente y violenta de los músculos del cuerpo. Cuando ocurren estas contracciones parece que el animal tentase de sacudir alguna cosa de su vellón. Mientras que el animal se sacude así hay un arqueo fuerte del dorso. Las piernas son generalmente muy juntadas como que fuesen recogidas bajo del cuerpo. Un ruido repentino causará el sacudir del vellon ya describido. Las contracciones de los músculos principian con la cara y con la cabeza, entonces pasan por el cuello y por el dorso y finalmente afectan las piernas. Después de ser envenenados, muchos animales dejan el rebaño sin ningún motivo y se ponen en marcha en una condición aturdida, plantando los pies delanteras alto y con la cabeza erguida. Se quedan en esta posición durante un minuto o más. Entonces hay un estremecimiento de los músculos de las piernas, del cuello y del dorso con una flaqueza repentina y una inconstancia de andadura. La oveja cae generalmente después y entra en espasmos. Las pupilas se dilatan y los sentidos de vista y de dirección son completamente trastornados. Tan pronto que cesan los espasmos hay un mascar de las mandíbulas, un babosear, un sacudir continuo de la cabeza y un temblor del cuello. Parece que todos los animales envenenados tuvuisen un deseo indomable de asir un objeto, tal que una piedra o un palito y masticarlo durante horas enteras.

Métodos de manejo para reducir pérdidas por "goldenrod."

Pérdidas enormes han resultado de que se ha dado a las ovejas del "goldenrod" mezclado con heno. Si el heno es destinado para ovejas es preciso determinar los terrenos donde crece el "goldenrod" y el heno de estes terrenós debe ser amontado en lugares particulares y dado al ganado o a los caballos, animales que hasta ahora parecen ser inmunes de los efectos venenosos de esta planta. Cuando se pasta las ovejas en terrenos donde crece el "goldenrod" hay que dejarlas la más grande libertad posible en su selección del forraje. Para mantener un apetito normal hay que darlas sal regularmente y en abundancia. Frecuentemente el "goldenrod" crece espesamente en pedazos de terreno particulares de resultas que es muy facil pastar las ovejas afuera de estos terrenos. Para hacer eso hay que conocer bien la planta y distinguirla de las otras. Placa V muestra bien la apariencia de esta planta. Cuando se seca el "goldenrod" mezclado con heno las flores amarillas generalmente se quedan en la planta de resultas que es muy facil encontrarlas si acaso se sospecha que la causa de pérdidas esté en el heno.

RABBIT BRUSH. (TETRADYMIA.)

Esta planta es venenosa durante ciertas sazones del año y en ciertas condiciones. Recientemente ha causado la pérdida de unas millares de ovejas en la parte occidental de Nevada.

Descripción.

El "rabbit brush" es un arbusto rígido de 1 a 4 pies de altura. Tiene ramos delgados y desplegados. Estos ramos son blanqueados por vellos lanosos y esterados. Las hojas son lisas y verdes. Las hojas sazonadas

son delgadas y rematadas en punta mientras que las verdes son gruesas y sin punta. Las flores son amarillas y son sostenidas en macollas. Placa VI muestra un ramo típico de este arbusto y en figura 17 se ve la manera típica de su crecimiento y de su ramificación. El "rabbit brush" espinoso se encuentra frecuentemente creciento junto con el "rabbit brush" antedicho. Es también un arbusto y de 3 a 4 pies de altura. Tiene los ramos muy separados. Estos son cubiertos por un vello espeso y blanqueado. Tienen espinas derechas o curvas en vez de las hojas principales. Según lo que se ya sabe el "rabbit brush" espinoso no es venenoso.

Distribución y terrenos donde crece el "rabbit brush."

Se encuentra el "rabbit brush" en terrenos áridos de artemisia. La vegetación característica con que crece consiste en artemisia, "bud sage," "white sage," "shad scale" y las salivas verdes (green sages). Frecuentemente se encuentra el "rabbit brush" donde no hay otra vegetación. So lo encuentra nunca en terrenos montañosos.

Animales que se envenenan.

Es probable que sólo las ovejas se envenenan.

Partes venenosas de la planta.

Durante la primavera este arbusto produce pimpollos y hojas en que pastan las ovejas. Estas partes de la planta han sido la causa de las pérdidas.

Cantidad de "rabbit brush" necesaria para matar.

Según lo que se sabe hasta ahora, una oveja para envenenarse tiene que pastar exclusivamente en esta planta hasta que el estómago está casi lleno. Las hojas verdes y tiernas y los pimpollos contienen dos por ciento más o menos de potasa, un veneno fuerte. Este veneno puede ser la causa de las pérdidas de ovejas. La mayor parte de las pérdidas en Nevada consistía en animales muy hambrientos o tales que eran mantenidos en haciendas durante todo el invierno y después eran conducidos por terrenos donde florecía el "rabbit brush."

Síntomas.

Después de que una oveja se ha llenado el estómago con vástagos de "rabbit brush" se pone muy torpe. Vacila y a veces cae de repente en condicion insensible con la cabeza torcida a un lado. Entonces sigue un espasmo de los músculos. Los ojos se comban y saltan a la vista. La respiración es muy ligera. La nariz y la cara se arrugan como si la nariz estuviera obstruida por cualquier obstáculo. Los animales que están tendidos en el suelo casi siempre trituran los dientes después de que se hinchan. Hay especialmente un hinchar de la cabeza y de las orejas en los casos de muchos de los animales envenenados. Un moco rayado por sangre viene de la nariz. El animal muere generalmente en un rato de cinco minutos a una hora después de caer.

Remedios.

Cuando una oveja está envenenada por "rabbit brush" hay poco que se puede hacer para curarla. Generalmente cuando hay casos de este envenamiento en un rebaño es probable que muchos animales están tendidos en el suelo al mismo tiempo así que un tratamiento particular es imposible.

Métodos de manejo para disminuir pérdidas por "rabbit brush."

Es posible evitar pérdidas casi enteramente en que se pasta los animales con cuidado. La cosa más importante es el saber que las ovejas comen esta hierba cuando están muy hambrientas o cuando hay carestía de otro forraje. El pastor debe aprender como se distingue este arbusto a primera vista. Cuando ve que las ovejas pastan casi exclusivamente en las partes tiernas y verdes de esta planta debe inmediatamente conducirlas a terrenos donde no hay "rabbit brush." Es especialmente preciso saber esto cuando se conduce los animales de un terreno a otro, cuando están en terrenos de pasto a lo largo de ferrocarriles, cuando están en los corrales de esquilar y después de que se los ha transportado una gran distancia de resultas que están muy hambrientos.

LOCO. LOCO WEED. (ASTRAGALLUS O ARAGALLUS.)

El nombre común de esta planta viene de que los animales envenenados parecen como si fuesen en un estado de locura.

Descripción.

En Nevada hay muchas especies diferentes de "loco," nigunas de las cuales causan grandes pérdidas. Los "locos" apartenecen a la familia de guisantes y tienen la flor típica del guisante. Esta flor se genera en colocación apretada cerca de la extremidad del pedúnculo y tiene varios tintes de púrpura, de amarillo, de blanco y de rojo. La vaina es generalmente hinchada en apariencia como la del guisante y contiene dos o más semillas pequeñas. Las hojas son de una estructura particular de resultas que se puede facilmente distinguir el "loco" de las otras plantas en los terrenos de pasto. Estas hojas son compuestas de muchas hojuelas que se adhieren a los dos lados del pecícolo. Hay siempre una hojuela sobrante en la extremidad del pecícolo come se ve en figura 19.

Distribución y terrenos donde crece el "loco."

Los "locos" son muy distribuidos por todo el estado de Nevada. Se los encuentra en todos los terrenos de pasto con excepción de los prados húmedos, los terrenos bien arboleados y los terrenos llenos de álcali.

Animales que se envenenan.

Todas clases de animales se envenenan por "loco" pero las ovejas y los caballos son mucho más susceptibles que el ganado vacuno. Las pérdidas en Nevada no son muy importantes y ocurren principalmente en la parte meridional del estado donde hay pocos animales en los ranchos a causa de la carencia de agua y de forraje.

Síntomas.

El "loco" afecta los animales de dos maneras: (1) por envenenamiento agudo después de que los animales mueren en pocos días y (2) por envenenamiento crónico después de que viven de seis meses a un año o más.

El síntoma más caracteristico de envenenamiento por "loco" es la falta de dominio exacto sobre los músculos de resultas que la andadura del animal es muy semejante a la de un borracho. El sentido de la vista se afecta y el animal no puede juzgar correctamente el tamaño y la distancia de objetos. En los casos más graves se queda enteramente ciego y el oído se afecta frecuentemente de un modo que el animal no

puede determinar de que dirección viene un sonido. El ganado vacuno y los caballos llevan la cabeza bajo generalmente, el pelo deviene muy áspero y la andadura es muy vacilante y lenta. En el caso de ovejas con frecuencia hay un arrojar de la lana general o en pedazos. El dorso es muy arqueado y especialmente hay un estremecimiento de las piernas y de las rodillas. Es casi imposible retener las ovejas envenenadas en rebaños o conducirlas en una dirección determinada. Muchas veces el sentido de la vista se afecta tanto que no pueden ir adelante con el rebaño de resultas que se las encuentra después muertas por los barrancos o ahogados en los riachuelos o en los abrevaderos.

Un resultado del pastar casi exclusivamente en "loco" es que al fin el animal muere de debilitación y de hambre. Un animal envenenado así se pone al fin muy abatido, los ojos son húmedos y generalmente se queda abandonado por hombres y por bestias. Se queda durante días y aun semanas en un terreno pequeño sin agua y con poco forraje hasta que la muerte lo relieve.

Métodos de manejo para reducir pérdidas por "loco."

Los "locos" capables de causar los síntomas caracteristicos son muy ingustables y los animales los tocan raramente excepto cuando están muy hambrientos o están en terrenos de pasto bien apacentados o por donde el "loco" es la planta predominante. En estas condiciones los animales comen el "loco" por fuerza. Cuando han desenvolvido un apetito para esta planta se la comen con preferencia a todo el otro forraje.

Cuando los animales pastan en terrenos infestados por "loco" hay que guardarlos bien y tan pronto que principian a dar signos de ser envenenados es preciso separar los que son así envenenados de los otros animales del rebaño, ponerlos en vallados y engordarlos. Si eso no es posible es preciso conducirlos a terrenos de pasto donde no hay "loco." Los animales desarrollan el hábito de comer "loco" cuando hay carestía de forraje sabroso y nutritivo. Después de que un animal ha adquirido el gusto para "loco" no se debe nunca dejarlo correr por terrenos donde crece esta planta. Para evitar que las ovejas desarrollen el gusto para "loco" es preciso pastarlas en formación abierta y dejarlas gran libertad en su escogimiento del forraje. También es importante dejarlas pasar la noche por donde se encuentran al anochecer y no conducirlas a un campamento particular.

Cuando las ovejas pasan algunas noches en el mismo terreno es natural que pastan antes en las plantas más sabrosas y dejan las otras, tales que los "locos" hasta al fin. Si continuan a pastar en el mismo terreno hasta que no hay más plantas sabrosas el resultado es que entonces comen el "loco" por fuerza y así desarrollan el gusto para esta planta venenosa. Además de eso, cuando el animal está muy hambriento no es muy escrupulosa en el escogimiento de su forraje. Por eso es importante conducir los rebaños de los terrenos donde duermen tan temprano que posible porque más tiempo que se quedan en estos terrenos más hambre tendrán de resultas que la probabilidad de que comerán del "loco" será muy aumentada. Especialmente hay que pastar los corderos con cuidado porque desarrollan el gusto para "loco" más facilmente que los animales más viejos. Si se separa los corderos de sus madres para algun rato durante que se pasta los rebaños apretadamente el resultado es que los corderos devienen muy hambrientos y en esta condición la probibilidad que comerán el "loco"

es muy aumentada. Es importante siempre proveer bastante sal para que no desarrollen apetitos perversos.

ELÉBORO SEUDO. (FALSE HELLEBORE.)

Los nombres comunes en los ranchos para esta planta son: "cow cabbage," "wild Indian corn," "Indian poke," "hierba fétida" (skunk cabbage), "bear corn" y "swamp hellebore."

Descripción.

Esta planta es de 2 a 6 pies de altura y tiene raíces gruesas y cortas. Las hojas son anchas, abrazadas, veteadas y alechugadas. Las flores y los tallos son cubiertos de un vello fino. Las flores son de color amarillo-verdusco o blanco-verdusco y amarillo. Figura 22 muestra el eléboro seudo como florece en los ranchos.

Distribución y terrenos donde crece el eléboro seudo.

Esta planta no es muy distribuida en Nevada. Sin embargo se la encuentra frecuentemente en ciertos terrenos montañosos donde el suelo es fértil y margoso y donde hay gran cantidad de agua.

Animales que se envenenan.

De lo que se sabe hasta ahora sólo las ovejas se envenenan. Se ha notado algunos casos de envenenamiento en ranchos bien pastados donde las ovejas habían comido vorazmente el eléboro seudo de resultas que todas se envenenieron y algunas murieron.

Síntomas de envenenamiento por eléboro seudo.

El primer síntoma notado consiste en una salivación copiosa acompañada por un vomitar o un tentar de hacerlo. En los casos de muchos animales hay una gran flaqueza de los músculos, estremecimientos, espasmos y una parálisis general. En los casos de todas las ovejas envenenadas y demasiado débiles para quedarse en pie la respiración es floja, la temperatura muy reducida, la piel fría y la vista afectada. La muerte por sofocación resulta finalmente.

Métodos de manejo para reducir pérdidas por eléboro seudo.

Las pérdidas consisten generalmente en corderos. Para evitar pérdidas por eléboro seudo hay que dejar las ovejas comerlo sólo moderadamente o de ningún modo. Como la plante crece en áreas bien definidas es enteramente practicable evitar que los animales pasten en ella exclusivamente y así no comerán bastante para hacerse daño.

IRRIGATION OF FIELD CROPS IN NEVADA

By
C. S. KNIGHT
and
GEORGE HARDMAN

BULLETIN No. 96

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1919

1[41]

NEVADA AGRICULTURAL EXPERIMENT STATION

CONTENTS

Introduction.
Nevada Water Supply and Drainage Areas.
- Humboldt River.
- Truckee River.
- Carson River.
- Walker River.
- Muddy River.
- Small Streams in Northern Nevada.
- Artesian Wells in Southern Nevada.
- Washoe Lake.

Irrigated Area in Nevada.
Methods of Irrigation.
- Flooding from Field Ditches.
- Flooding in Borders.
- Flooding in Checks.
- Furrow Irrigation.

Important Factors Affecting Duty of Water in Nevada.
- Type of Soil.
- Topography.
- Hardpan Near the Surface.
- Annual Rainfall.
- Evaporation.
  - Soil Mulches of Different Depths.
  - Cultivation at Different Depths.
  - Shallow- and Deep-Furrow Irrigation.
- Overirrigation.

Irrigation Investigations.
- Early Investigations on Duty of Water.
  - (a) Duty of Water on Alfalfa at the Experiment Station, 1906–1911.
  - (b) Duty of Water Under Field Conditions in the Carson Valley, 1907.
- Recent Investigations on Time and Amount of Irrigation and Soil Moisture Content.
  - Alfalfa.
  - Wheat.
  - Potatoes.
  - Red Clover.
  - Sugar-Beets.

Summary.

IRRIGATION OF FIELD CROPS IN NEVADA

By C. S. KNIGHT and GEORGE HARDMAN

INTRODUCTION

The approximate area of land in the State of Nevada is 70,285,440 acres. Of this amount about 900,000 acres, or 1.3 per cent, were irrigated in 1918. The State abounds in rich agricultural land, but the lack of additional water for irrigation prevents the cultivation of regions which are now lying idle as waste desert areas. To increase the area of irrigated land it becomes necessary either to furnish additional water by means of artesian wells or pumping, or to make a more conservative use of the present water supply. The irrigation experiments at the Nevada Station deal chiefly with the latter of these two methods.

Alfalfa, wheat, and potatoes are three of the most important cultivated crops grown in Nevada. Practically all of the alfalfa, most of the wheat, and all of the potatoes are grown under irrigation. In the course of the last nine years the acreage of alfalfa in this State increased from 89,000 to about 145,000 acres, or over 60 per cent; and the yield from 235,000 to about 500,000 tons, or an increase in production of 112 per cent. In 1918 about 80,000 acres of wheat were raised in Nevada, with a production of about 2,000,000 bushels. Approximately one-third of the crop was grown in Humboldt County, and over 80 per cent in Humboldt, Washoe, Churchill, Lyon, and Douglas Counties. The potato crop for the same year amounted to about 15,000 acres, with a production of approximately 75,000 tons. Over 60 per cent of this crop was produced in Lyon, Churchill, Washoe, and Douglas Counties.

A large part of the acreage of these crops in Nevada receives too much water to obtain the best yield and quality of crops, and for maintaining high-producing soils. The common practice in Nevada is to irrigate alfalfa at regular intervals with little regard to the actual needs of the crop for water, or to the possible injury to the soil by excessive irrigation. It is important, therefore, that the proper method of irrigation and the best time and depth of application be known. Furthermore, in years of water shortage irrigations should be omitted at those stages of growth when the crop is least affected. Pumped water is expensive as compared with surface water; hence, it is of value to the grower to know the least amount of water necessary to obtain the best results with the various crops. Since the supply of water is strictly limited and the supply of irrigable land is practically unlimited, it becomes of vital importance to the State to have authentic information on the most economical amounts of water to apply, consistent with profitable returns.

In view of the above facts, a series of experiments has been conducted during the last five years by the Nevada Agricultural Experiment Station comparing the different methods of application to determine the amount of water required and the best time to apply water to the

NOTE—The authors are indebted to J. B. Menardi who assisted in the field work during the three-year period, 1914–1917; also to F. L. Bixby, Senior Irrigation Engineer, U. S. Department of Agriculture, for valuable suggestions, assistance, and diagrams.

crop to obtain the most favorable results; at which stage or stages of growth an application may be eliminated without seriously affecting the yield of grain; and also the most practical depths of applications when only two irrigations are possible. The average results of experiments on the irrigation of wheat, alfalfa, potatoes, red clover, and sugar-beets, together with results of earlier work on alfalfa, wheat, and barley, are given in this bulletin.

NEVADA WATER SUPPLY AND DRAINAGE AREAS

Nevada lies almost wholly within the Great Basin. In fact, with the exception of small streams tributary to the Snake River in the northeastern section of Nevada and some branches of the Colorado River in the southeastern section, the rivers drain into the interior of the State. These rivers are fed from the snowfall on the mountains of Nevada and the eastern slope of the Sierra in California. The Humboldt, Truckee, Carson, Walker, and Muddy are the principal rivers supplying water for irrigation.

Humboldt River.

This river has a length of 350 miles of air line, but measured in its irregular course it traverses a distance of about 1,000 miles. The melting snows of the Ruby, East Humboldt, Independence, and Diamond ranges are the sources of this river; it drains into the Humboldt Sink at the lower end of the Lovelock Valley. This stream has a drainage basin of 13,800 square miles, all within Nevada. More than 50 per cent of the irrigated area in this State receives its water from the Humboldt River.

Truckee River.

This is the most northerly river on the eastern slope of the Sierra emptying into the Great Basin. It receives its water supply chiefly from mountain lakes, which are fed by the melting snow of the Sierra in California. It is the outlet of Lake Tahoe, which has an elevation of 6,225 feet and covers an area of 193 square miles. The course of the Truckee is about 110 miles long, in which distance it has a total fall of 2,350 feet. It has a drainage basin of 2,310 square miles.

Carson River.

This river is formed by the East and West Forks, which receive their water supply from the melting snow on the eastern slopes of the Sierra Nevada in California. The river is about 120 miles long and has a total fall of 1,900 feet. It has a drainage basin in Nevada of 988 square miles.

Walker River.

This is the most southerly river draining from the Sierra Nevada into the Great Basin. It is formed by the East and West Forks, whose basins are separated by the Sweetwater range of mountains. The East Fork is fed by the melting snows from the eastern slope of the Sweetwater range and the western slope of the Walker River range, while the West Fork drains part of the eastern slope of the Sierra. This river is about 120 miles long, has a total fall of 1,600 feet, and a drainage basin of 2,420 square miles.

Muddy River.

The Muddy River is located in the southeastern part of Nevada. It receives its supply of water from constantly flowing springs in Arrow Canyon, and drains into the Virgin River, a tributary of the Colorado River. It has been estimated that the average annual flow of the river is about 28,000 acre-feet of water.

Small Streams in Northern Nevada.

The small streams in northern Nevada furnish water for about 14 per cent of the total irrigated area. The principal streams are the White River, Duck Creek, Steptoe Creek, Salmon River, Bruneau River, and Owyhee River. The White River is 75 miles long, and has an average annual run-off of about 28,000 acre-feet. Duck Creek and Steptoe Creek supply Steptoe Valley, and the Salmon, Bruneau, and Owyhee irrigate a considerable area in Nevada before emptying into the Snake River basin.

Artesian Wells in Southern Nevada.

In southern Nevada about 100 artesian wells, which develop flows at from 200- to 400-feet depths, furnish the water supply for the irrigation of a considerable area, the greater portion of which is located in the Las Vegas and Pahrump Valleys.

Washoe Lake.

By means of large pumping plants several thousand acres of land have been placed under intensive cultivation with the water from Washoe Lake. The water is elevated from 40 to 125 feet by the different plants.

IRRIGATED AREA IN NEVADA

The following table taken from the twelfth and thirteenth census of the United States, shows the total irrigated area in Nevada for 1900 and 1910, with the increase in per cent for the ten-year period:

IRRIGATED AREA BY COUNTIES IN NEVADA—ACREAGE

County	*1900*	*1910*	*Increase per cent*
The State	504,168	701,833	39.2
Churchill	29,533	35,114	18.9
Clark	(a)	8,116	....
Douglas	25,861	32,181	24.4
Elko	156,446	183,552	17.3
Esmeralda[b]	6,181	14,011	126.7
Eureka	21,831	18,715	14.3
Humboldt	124,959	207,753	66.3
Lander	18,803	23,342	24.1
Lincoln[a]	9,962	9,907	(a)
Lyon	32,422	62,148	91.7
Nye	12,666	19,978	57.7
Ormsby	1,563	2,426	55.2
Storey	690	891	29.1
Washoe	43,855	50,904	16.0
White Pine	19,366	32,795	69.3

It is noted from this table that about 30 per cent of the total irrigated area is located in Humboldt County and 56 per cent in Humboldt and Elko Counties, this area being irrigated from the Humboldt River and its tributaries.

[a]Change in boundary. Lincoln County divided into Lincoln and Clark Counties.
[b]Change in boundary. Esmeralda County divided into Esmeralda and Mineral Counties.

Methods of Irrigation.

The greater portion of the alfalfa acreage in Nevada is irrigated by some form of flooding. In the Lovelock Valley the border method of flooding is generally used; on the Truckee-Carson Project, the check system of flooding; in Washoe Valley, flooding from field laterals and by the furrow method; and in the Carson Valley the furrow or corrugation method is most common.

On light sandy soils it is very important to have available a sufficient head of water to flood the field in a short time so that very little water will be wasted by percolation through the soil beyond the depth of the plant roots. With the heavy clay loam or clay soils a relatively small head of water is required for a longer period of time, since the water percolates less rapidly through these soils. The heavy soils, however, have greater power for retaining water, and are better suited to fewer and heavier irrigations. Frequent light applications of water generally result in the best crops on the sandy and sandy-loam soils. Each

Plate 2—An excess of water is used in this method of flooding.

method of irrigation is peculiarly adapted to the soil conditions and slope of the land in the district where it is practiced.

Flooding from Field Ditches.

This is the cheapest method to install and the most wasteful of water, also a great deal of labor is required in distributing the water over the field. It is sometimes called the contour method, since the field ditches carry the water along the ridges and distribute it down the slopes over the field. This method is applicable to new lands for the first crop; to heavy, rocky, or very shallow soils where leveling is not advisable; and to small heads of water. One man can handle from two to four second-feet of water under this system.

Flooding in Borders.

Flooding in borders or border checks, where the land is comparatively level and does not bake excessively, is one of the most satisfactory methods of irrigation for either grain or alfalfa. This system is

practiced in Nevada on comparatively level land where a large head of water is obtainable. In preparing the land for this system, great care must be exercised in leveling the land between the border levees. For the rough leveling a Fresno scraper is commonly used, being followed by a tailboard scraper to make the levees. Another commonly used implement in Nevada is a large scraper mounted on four wheels with a heavy iron blade which works something on the order of a road grader. Where the levees are constructed with the tailboard scraper the operator drives across the field in the opposite direction to the levees, gathering the dirt for the levees from the surface of the borders, and at the same time leveling the borders.

The borders vary in length from 300 to 1,300 feet, with an average of 500 feet depending upon the slope of the land and the texture of the soil. The width may vary from 30 to 100 feet, with an average of about 60 feet. In irrigating, the water is turned into the border and carried down its entire length, the waste water either being picked up by the head ditch of the next series of border checks, or flowing into a drainage ditch. One man can handle about six second-feet of water under this method.

The system of border irrigation, practiced to a large extent in the Lovelock Valley, differs from the method explained above as follows:

When the field is properly leveled with a grader, the borders are marked off on the head line from sixty to ninety feet wide. A large V marker or ditcher is then used to make the levees, separating the borders at regular intervals. This is a heavy implement, mounted on four wheels, controlled by a system of levers, and requiring about sixteen horses for its operation. After these borders are seeded, a head ditch is then made with the same ditcher to carry the water to the borders. If one man is applying the water, he turns in as large a head as can be properly handled. Considerable experience is needed in this system of applying water, because, as soon as the soil at the upper ends of the borders is sufficiently wet, the water must be taken down the ditches between the borders to irrigate the lower portions of the land. These borders vary from 1,000 to 5,000 feet in length, depending upon the slope of the land. With a properly installed system the water can be brought down one side of the field for a considerable distance in a diagonal direction, instead of bringing the water down the ditch and turning it into the borders at frequent intervals. In this way a large tract can be irrigated in a day by one man. The ground is flooded for the first irrigation only, subsequent applications being made by allowing the water to seep from the ditches between the borders. In sections of Nevada where this system is practiced, wonderful crops of wheat and alfalfa are produced, but in such regions the soil is of a loose nature, contains a large amount of humus and does not bake after wetting. In this system one experienced irrigator can handle about six second-feet of water.

Flooding in Checks or Basins.

In this system of irrigation the levees are run across the field in both directions, dividing it into a series of checks or basins. In Nevada this method is largely practiced on new lands that require a great deal of leveling. The level tracts can be checked ready for the water with less expense than for any other system of flooding. This method is also

desirable on lands that will not soak up readily when the water is run in furrows. On the Newlands Irrigation Project, where this system is commonly used in the production of hay and grain, the levees dividing the checks or basins are wide and low, and are generally covered with a crop. They are so constructed to prevent any waste of land and to make possible the harvesting of the crop with a mower or binder. In such a system some checks are higher than others. Water is turned into the higher checks, and, when the ground is sufficiently wet, it is taken off and run into the lower checks, and so on, until all the ground is irrigated. Although considerable water is lost by evaporation, very little goes into the drainage ditches. If the land has a gentle slope, the installation of this system is expensive as compared with the border method and flooding from field laterals. A large head of water can be

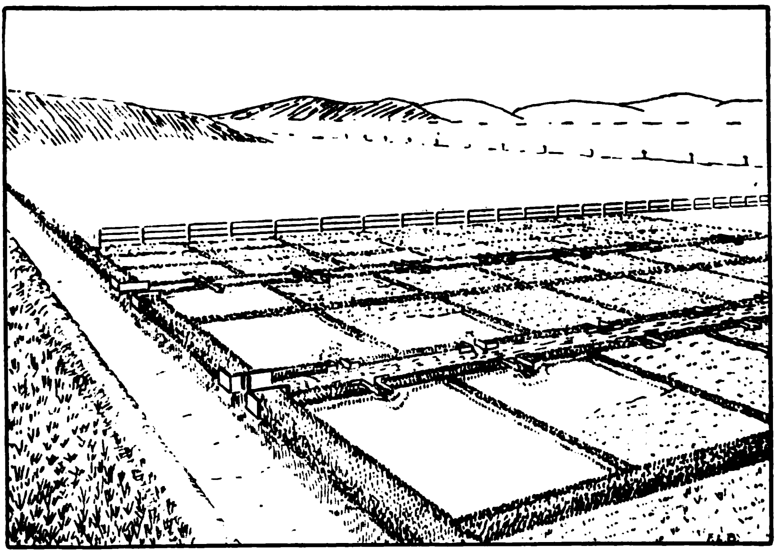


Plate 3—Check method of irrigation.

used with this system and one man can handle from seven to eight second-feet. On the Newlands Project the check system is being rapidly replaced by the border method.

Furrow Irrigation.

Where the conditions are suitable and the land is sufficiently friable and mellow, the furrow method of irrigation is best adapted to the highest returns of hay and grain in Nevada. In this system the water is run through the field in small furrows and diffused laterally through the soil, but should not run over the surface. This system is adapted to small irrigating streams, considerable slopes, and heavy soils. The water may run in few or many furrows, or it may be run across the slope at any angle for the desired flow of water giving the heavy soils time to soak up. The feed ditches are nearly level and are generally

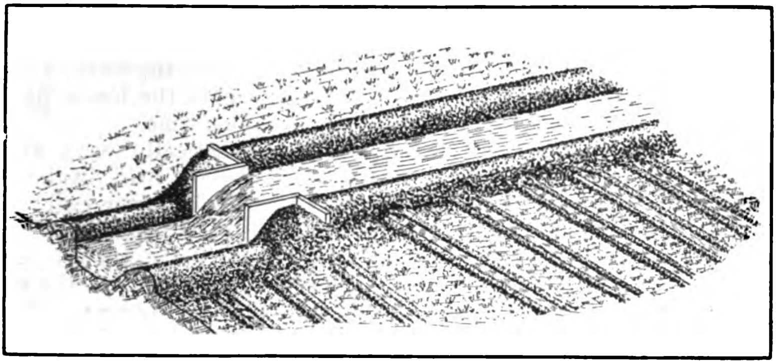


Plate 4—Furrow irrigation by means of pipes.

run across the slope of the field. In Nevada a great deal of trouble has been encountered on light soils in the washing away of the banks where the water is taken from the distributing ditch to the furrows. This condition has been met by the use of galvanized iron pipes from one and one-half to two inches in diameter and two feet long, or by the use of wooden spile made from lath or material sawed for the purpose. These pipes are placed in the bank of the distributing ditch and each pipe furnishes water for two to six furrows, depending upon the head

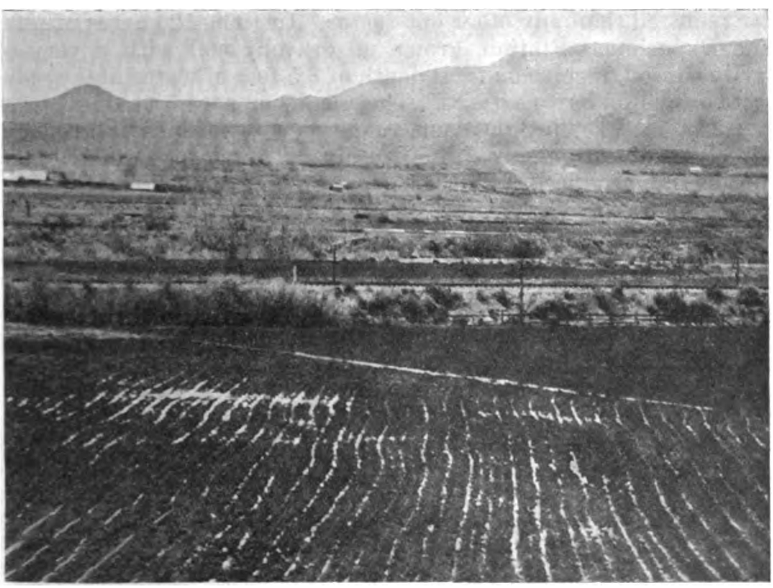


Plate 5—A minimum amount of water is used in the furrow method of irrigation.

of water in the feed ditch. By such a system a large field can be irrigated by one man, since his chief duty is to see that the proper head of water is maintained in the distributing ditches; also, the water is more evenly distributed in the furrows, so that it reaches the lower part of the field in the different furrows, at about the same time.

On the heavy soils of the Truckee Meadows practically every alfalfa field is furrowed, but the land is usually flooded from field ditches, the furrows providing easy channels for the water to the lower end of the field and drainage for the surplus water after each irrigation, which might otherwise stand in the low places and retard the growth of the crop. In irrigating grain more care must be taken to prevent the water from flooding the surface of the ground between the furrows.

The furrows vary in length with the slope of the land and the nature of the soil from 200 to 800 feet, the longer furrows being possible on the heavier lands with gentle slopes. Feed ditches run across the fields at intervals of from 200 to 800 feet, and in turn furnish water for the irrigation of the furrows below. Although the initial expense of installing this system is high, the water is easily handled and the expense of irrigating is small. A smaller head of water is used with this system than with the others.

IMPORTANT FACTORS AFFECTING DUTY OF WATER IN NEVADA

Type of Soil.

The type of soil probably causes greater variation in the amount of water required than any other one factor. In 1906, 12½ acres of alfalfa, at the Experiment Station, grown on gravelly soil with a very open gravelly subsoil, received a total depth of 8.5 feet of water and produced only two tons of hay per acre. The yield per acre-foot of water was only 0.24 tons. During the same year two acres of alfalfa grown on a sandy clay soil with a clay subsoil received a total depth of only 3 feet of water and produced 7.36 tons per acre or a yield of 2.45 tons per acre-foot of water.

Topography.

On lands that are rolling or that have steep slopes the amount of run-off is large, thus increasing the total irrigation required to produce the best crops. On the more uniformly level lands with light slopes practically all of the water applied may be retained by the land. On certain alfalfa fields in the Truckee Meadows, where the land is rolling, the total annual depth of irrigation varies from 5 to 10 feet, but more than one-half of this amount may be run-off that is used again on lower lands or drains back into the Truckee River.

Hardpan Near the Surface.

The following table shows the results obtained in 1910 on an acre of alfalfa, which received twelve irrigations with a total of about six acre-feet of water:

EFFECT OF HARDPAN ON THE AMOUNT OF WATER REQUIRED FOR ALFALFA*

Date of irrigation—		Depth of irrigation, feet	Yield per acre First cutting, tons	Second cutting, tons	Third cutting, tons
April 19	0.126				
April 20	0.239				
May 5	0.408				
May 23	0.646				
June 3	0.662				
Total		2.081	1.65		
June 16	0.759				
June 27	0.537				
July 7	0.225				
July 8	0.436				
Total		1.957	......	1.55	
July 29	0.523				
August 6	0.676				
August 12	0.661				
Total		1.860	......	......	1.77
September 14	0.390	Irrigation for pasture			
Total irrigation	6.288		Total yield		4.97

*A heavy clay soil with a hardpan layer very close to the surface. The depth of irrigation includes run-off which was not measured.

It is noted from these results that soils with hardpan near the surface have very little capacity for retaining water, and in this instance about twice as much water is used to produce a crop as compared with similar soils without a hardpan layer near the surface.

Influence of Annual Rainfall.

In many States where irrigation is practiced the annual precipitation is an important factor to be considered in the results of investigations of irrigation methods, and particularly in the duty of water in field practice. The following table gives the total precipitation and monthly distribution for the past five years and for a period of eighteen years at the Experiment Station:

MONTHLY PRECIPITATION IN INCHES AT THE AGRICULTURAL EXPERIMENT STATION, FIVE-YEAR PERIOD, 1914–1918*

Month	1914	1915	1916	1917	1918	Average five years	Average 1900-1918
January	5.46	0.55	6.76	0.05	0.13	2.59	1.99
February	0.86	2.59	0.59	2.01	1.73	1.56	1.20
March	T	0.16	0.33	0.74	2.51	0.75	0.97
April	*0.70*	*0.33*	*0.11*	*0.28*	*0.16*	*0.32*	*0.52*
May	*0.11*	*0.52*	*T*	*1.18*	*0.25*	*0.41*	*0.48*
June	*0.29*	*0.00*	*0.11*	*0.06*	*0.14*	*0.12*	*0.25*
July	*T*	*0.04*	*T*	*0.04*	*T*	*0.02*	*0.44*
August	*0.38*	*T*	*0.04*	*0.12*	*T*	*0.11*	*0.32*
September	*0.05*	*0.06*	*0.35*	*T*	*2.41*	*0.57*	*0.33*
October	0.16	T	1.13	T	0.75	0.41	0.41
November	T	0.28	0.05	0.68	0.37	0.28	0.51
December	0.70	1.09	0.97	0.27	0.40	0.69	0.89
Total	8.71	5.62	10.44	5.43	8.85	7.83	8.31

*Information secured from the U. S. Weather Bureau, Reno, Nevada.

It will be seen from the above table that the average annual precipitation for the five-year period of irrigation investigations amounted to 7.83 inches. In May, 1917, the rainfall was 1.18 inches. With this exception, during no one month of the growing season throughout the five-year period was sufficient rainfall received to affect the moisture content of the soil; that is, the small amount of precipitation at any one time was subject to evaporation within a few hours. The entire rainfall in September, 1918, occurred after the crops were harvested. The results of these experiments are therefore based entirely on the water supplied by irrigation.

The average precipitation over the entire State, according to the reports of the United States Weather Bureau, is about 8.5 inches per year. The only source of Nevada's water supply is the snowfall upon her own mountain ranges and the precipitation upon the eastern slope of the Sierra in California. Throughout the agricultural districts of Nevada the rainfall is, in general, so slight and so poorly distributed during the growing season that it cannot be depended upon to supplement irrigation in supplying the moisture needs of crops.

Effect of Evaporation on the Amount of Water Required.

The following table gives the average evaporation by months at the Experiment Station from still water surfaces for the year 1912:

EVAPORATION FROM WATER SURFACES AT THE EXPERIMENT STATION IN 1912

Month	*Evaporation, feet*
January	0.101
February	0.143
March	0.110
April	0.289
May	0.569
June	0.867
July	0.950
August	0.951
September	0.608
October	0.452
November	0.182
December	0.134
Total	5.356

The annual evaporation from free water surfaces at the Experiment Station is shown to exceed five feet, the greatest losses occurring during the months of June, July, and August. At the Experiment Station on cultivated land the average loss of water annually by evaporation amounts to about fifteen inches. It is quite evident from these results that where the annual evaporation is high, more water is required to produce a crop than in districts where the normal conditions of evaporation prevail.

During the years 1908 and 1909 the Nevada Agricultural Experiment Station, in cooperation with the Office of Irrigation Investigations of the U. S. Department of Agriculture, conducted a series of experiments on the losses of water by evaporation from irrigated soils. These investigations were made at the Experiment Station Farm near Reno at an altitude of 4,490 feet on a sandy alluvial loam soil, which is typical of a large portion of the irrigated area in Nevada. The detailed results of these experiments are found in Bulletin 248, Office of Experiment Stations, U. S. Department of Agriculture. A summary of the results of this work follows.

Effect of Soil Mulches of Different Depths.

The following table gives the average evaporation from soils protected by different depths of soil mulches at the Nevada Agricultural Experiment Station for a period of three weeks (June 9–30, and September 1–22, 1908), with six inches of water applied:

Depth of mulch	*Loss in inches*	*Loss of total application, per cent*
Water surface	4.68	78.0
No mulch	1.41	23.6
3-inch mulch	0.88	14.6
6-inch mulch	0.36	6.0
9-inch mulch	0.17	2.9

The unmulched surface shows a loss, during the three weeks, of 23.6 per cent of the six inches of water applied. The use of the 3-inch mulch shows a loss of 62.5 per cent, the 6-inch mulch a loss of 25.5 per cent, and the 9-inch mulch a loss of 12 per cent, respectively, of the loss from the unmulched surface. These results indicate the value of a soil mulch when land is prepared for cropping and when possible during the growing season, especially with cultivated crops.

Effect of Cultivation at Different Depths.

The following table gives the average evaporation losses from cultivated and uncultivated surfaces at the Nevada Agricultural Experiment Station for a period of twenty-eight days (May 7–June 4, and June 8–July 6, 1909), with six inches of water applied:

Cultivation	*Loss in inches*	*Loss of total application, per cent*
Water surface	8.49	......
Cultivated six inches	1.09	18.2
Uncultivated	1.51	25.2

Duplicate tests were made in this experiment, and where cultivation was given, the soil was stirred to a depth of six inches in a manner similar to natural field methods. The cultivated surface showed a loss of 72.2 per cent, or a saving of 27.8 per cent of that receiving no cultivation, thus verifying the results previously mentioned in the value of cultivation to form a soil mulch in preventing the loss of water from the soil by evaporation.

Effect of Shallow- and Deep-Furrow Irrigation.

The following table gives the average evaporation losses from surfaces irrigated by flooding, and with furrows of different depths at the Nevada Agricultural Experiment Station for a period of twenty-eight days (July 8–August 5, and August 10–September 7, 1909), with six inches of water applied:

Depth of furrow	*Loss in inches*	*Loss of total application, per cent*
Water surface	11.13	......
Flooded	1.05	17.5
3-inch furrow	0.91	15.2
6-inch furrow	0.73	12.2
9-inch furrow	0.55	9.2

The results of this experiment show that water run in furrows, 3, 6, and 9 inches deep, caused a saving of 13.3 per cent, 30.5 per cent and 47.6 per cent, respectively, of the total loss from the flooded surface during this period of 28 days. Where the supply of water for irrigation is limited and the corrugation method of applying water is practical the use of furrows from 6 to 9 inches deep will undoubtedly

result in greatly decreasing the loss of water from the soil by evaporation.

Overirrigation.

The use of excessive amounts of water tends to cause considerable losses from surface run-off and deep percolation. At the same time the quality and very often the quantity of the crop are reduced. Excessive irrigation of a wheat crop tends to produce a soft, mealy kernel that is not good for milling purposes. The experience of the Experiment Station with Marquis wheat under irrigation indicates that it is possible to produce a good grade of hard wheat with proper irrigation. After six years under irrigation this wheat ranks equal to the best wheat from the hard wheat sections of the Middle West. Overirrigation of alfalfa produces coarse stems and a smaller proportion of leaves. Potatoes become knotty and produce a second growth when given too much water.

EARLY INVESTIGATIONS

Duty of Water on Alfalfa.

The following table shows the average results in total irrigation, yield per acre and yield per acre-foot of water:

DUTY OF WATER ON ALFALFA AT THE EXPERIMENT STATION, 1906–1911

Year	No. of plat	Size of plat, acres	Total irrigation, feet	Yield per acre, tons	Yield per acre-foot of water, tons
1906		2	3.00	7.36	2.45
Average			3.00	7.36	2.45
1907	20	1	3.47	5.63	1.62
	22	1	2.80	5.11	1.82
	24–25	2	2.93	7.04	2.40
Average			3.07	5.93	1.93
1908	20	1	4.32	7.12	1.54
	21	1	3.30	6.02	1.69
	22	1	2.47	6.04	2.20
	23	1	2.92	5.66	1.46
	24–25	2	4.76	5.13	1.02
Average			3.55	5.99	1.58
1909	15		2.22	4.35	1.95
	16		3.48	4.23	1.21
	24		5.28	6.57	1.22
	25		2.98	6.21	2.09
	26, 27, 28		3.57	4.15	1.16
	20		2.54	6.94	2.73
	21		2.33	6.50	2.78
	22		3.76	4.60	1.22
	23		2.21	6.22	2.81
Average			3.15	5.53	1.91
1910	20		5.08	7.52	1.48
	21		3.05	6.61	2.16
	22		2.76	5.92	2.14
	23		2.61	6.35	2.43
	24		5.78	6.59	1.14
	25		3.58	6.02	1.68
Average			3.81	6.50	1.84
1911	20		3.64	5.15	1.41
	21		2.66	5.31	1.99
	22		2.25	4.56	2.02
	23		2.17	4.27	1.96
	24		3.87	3.34	0.86
	25		3.87	3.15	0.81
Average			3.08	4.30	1.51
Average for 6-year period, 1906–1911			3.27	5.93	1.87

NOTE—Sandy clay soil. Water measured from weir-box at an average distance of one-fourth mile from plats, applied under field conditions. Waste water from plats not measured.

It is noted that the greatest average annual total irrigation of 3.81 feet was given in 1910 with the second highest yield of 6.50 tons per acre or slightly above the average for the six-year period. During every other year the average total irrigation was less than 3.6 feet, or averaging 3.17 feet. The highest yield of 7.36 tons per acre was obtained in 1906 with a total irrigation of three feet of water. The average results for the six-year period show a yield of 5.93 tons per acre with a total irrigation of 3.27 feet, or at the rate of 1.87 tons per acre-foot of water.

Duty of Water on Crops Under Field Conditions in the Carson Valley, 1907.

In 1907 the Experiment Station in cooperation with Irrigation Investigations, United States Department of Agriculture, made a number of water duty determinations on the ranch of the Dangberg Land & Cattle Company in the Carson Valley. The following table gives the results of these determinations, including number of irrigations, depth of irrigation, yield per acre, and yield per acre-foot of water:

DUTY OF WATER ON FIELD CROPS AT THE DANGBERG RANCH, CARSON VALLEY, 1907*

ALFALFA

Crop	*No. of irrigations*	*Total irrigation, feet*	*Date of cutting*	*Yield per acre, tons*	*Yield per acre-foot of water, tons*
		Field No. 1—81.32 Acres			
Alfalfa and Timothy, first crop	3	3.16	July 22–26	3.87	1.23
Alfalfa, second crop	3	2.71	Oct. 4–8	2.46	0.90
Total		5.87		6.33	†1.06
		Field No. 2—80.50 Acres			
Alfalfa, first crop	2	3.08	July 1–4	1.68	0.55
Alfalfa, second crop	2	2.24	Sept. 5–8	1.49	0.66
Total		5.32		3.17	†0.60
		Field No. 3—102.66 Acres			
Alfalfa, first crop	3	3.40	Aug. 16–20	2.92	0.85
Alfalfa, second crop. (Used for pasture balance of the season.)					
Total		3.40		2.92	
		Field No. 8—50 Acres			
Alfalfa, first crop	3	2.94	July 22–23	3.40	1.16
Alfalfa, second crop	2	2.02	Sept. 18–20	2.40	1.18
Total		4.96		5.80	†1.17
Average for fields 1, 2, and 8		5.38		5.10	0.95

BARLEY AND WHEAT

		Field No. 1		*bushels*	*bushels*
Barley	3	2.88		61.10	21.48
		Field No. 2			
Barley	3	2.68		84.50	31.50
		Field No. 3			
Barley	3	2.48		78.60	31.70
Average—Barley	3	2.68		74.70	28.29
Wheat	2	2.33		44.00	19.00

*The yields shown in these tables are the results of common practice on the Dangberg ranch, one of the largest cultivated ranches in the State. The land represented by these fields was in a high state of cultivation, contained an excellent stand of alfalfa, and was irrigated by the furrow method. The depth of irrigation includes run-off, which was not measured.

†Average.

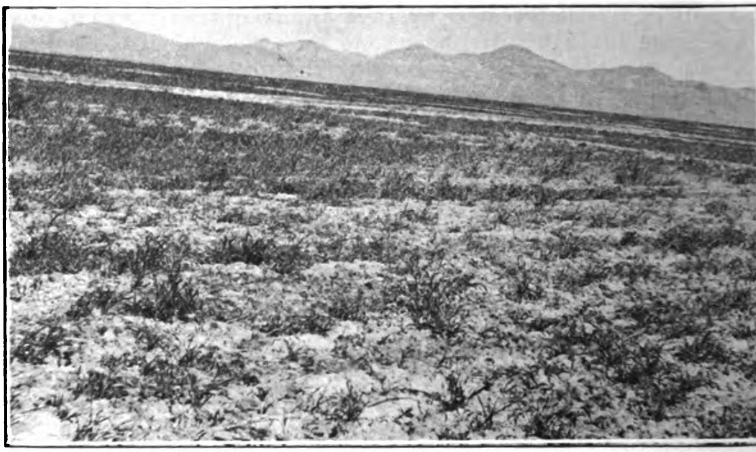


Plate 6—Overirrigation brings an excess of alkali to the surface. Note the thin stand of wheat on this land.

The average results for fields 1, 2 and 8 shows a yield of 5.1 tons of alfalfa per acre with a total irrigation of 5.38 feet, which gives a yield of 0.95 tons per acre-foot of water. The three fields of barley show an average total irrigation of 2.68 feet with a yield of 74.7 bushels, and a yield per acre-foot of water of 28.29 bushels. One field of wheat gave a production of 44 bushels per acre and 19 bushels per acre-foot of water with 2.33 feet applied.

RECENT INVESTIGATIONS

General Plan

Location and Soil Conditions.

This investigation of the irrigation of field crops was conducted at the Agricultural Experiment Station Farm at Reno during the five-year period, 1914–1918. The soil on these fields varies from a sandy loam to a clay loam, has an average depth of four feet, and is underlaid with coarse sand and gravel.

Plate 7—Method used in setting calibrated pipes.

The land was maintained in a relatively high state of fertility during the period of the experiment.

Measurement of Water.

The water applied to each plat was carefully measured by running it through calibrated iron pipes two inches in diameter by twenty-four inches long, set level in the bank of the distributing ditch and in the same horizontal plane. This provided for the measurement of water as it entered the plat, eliminating any possible error due to evaporation or seepage in the distributing laterals which often occurs when the measuring device is located at a distance from the plat. The head of water was constantly maintained at four inches by providing an overflow into a drainage ditch. The applications were so regulated that all of the water applied was used by the plats, thus preventing any run-off.

System of Checking.

To prevent any appreciable error due to variation in soil, a very

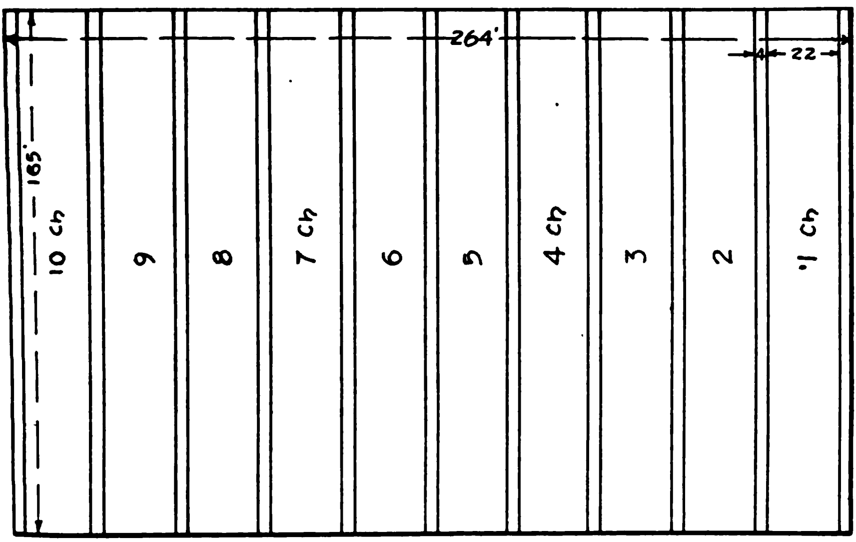


Plate 8—Irrigation of Wheat. Arrangement of plats and checks.

careful system of checks was used, their frequency varying with the size of the experimental plats. With wheat, potatoes and sugar-beets every third plat was a check. Thus, by revising the actual yields of the plats in accordance with the checks, the variation in yields due to the difference in soil was largely removed.

Harvesting.

In harvesting the crops in this experiment the outside portion of each plat was eliminated to prevent as far as possible any error due to seepage from adjacent plats. With wheat, alfalfa, and clover a four-foot cut was made around each plat, and the remaining areas were carefully measured before harvest. The two outside rows were eliminated from the potato and sugar-beet plats.

Soil Moisture.

Soil moisture determinations were made each year before the first

irrigation and at various intervals during the period of growth of the crops. Soil samples were taken from three locations in each plat for each foot to a depth of four feet. The object of these investigations was to determine the effect of different methods of irrigation on the soil moisture content at various periods of growth.

IRRIGATION OF ALFALFA

The irrigation experiment with alfalfa was conducted during the four-year period, 1915–1918, and included twelve plats, each 23 feet wide by 290 feet long. The plats were separated by levees four feet wide and high enough to prevent any overflow from one plat to another.

The alfalfa was irrigated by the furrow method, small furrows being

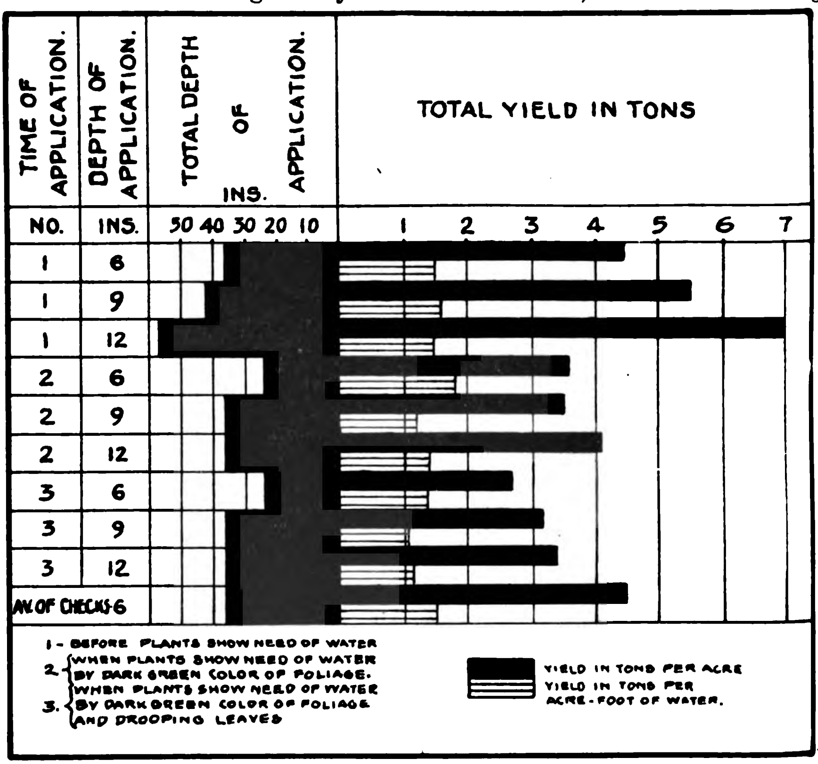


Plate 9—Irrigation of Alfalfa. Average results for the four-year period, 1915–1918, showing effect of irrigation on yield per acre and yield per acre-foot of water.

used at intervals of three feet to provide a ready channel for water to the lower ends of the plats. Water was measured into each plat through three pipes, the length of time required for an application varying from three hours forty-five minutes with the six-inch irrigation, to seven hours thirty minutes with the twelve-inch irrigation. Three check plats were used to prevent as far as possible any error due to variation in the soil. Six-, nine-, and twelve-inch applications were given at the following stages of wilting:

1. Before plants showed need of water.
2. When plants showed need of water by dark-green color of foliage.
3. When plants showed need of water by dark-green color of foliage and drooping leaves.

The checks were irrigated with nine-inch applications at the first stage of wilting. The alfalfa was harvested at the beginning of growth of the basal shoots from the crowns of the plants, or in the early bloom. Two cuttings were made each year of the experiment, the first cutting early in July and the second early in September. Samples representing the two cuttings from each plat were selected for determination of moisture and nitrogen content.

In this experiment a study was made of the depth of application, total irrigation, water and nitrogen content of plant, proportion of leaves to stems, yield per acre, and yield per acre-foot of water, in relation to the different stages of wilting, the results of which are included in the following table:

IRRIGATION OF ALFALFA

Average Results for the Four-Year Period, 1915–1918

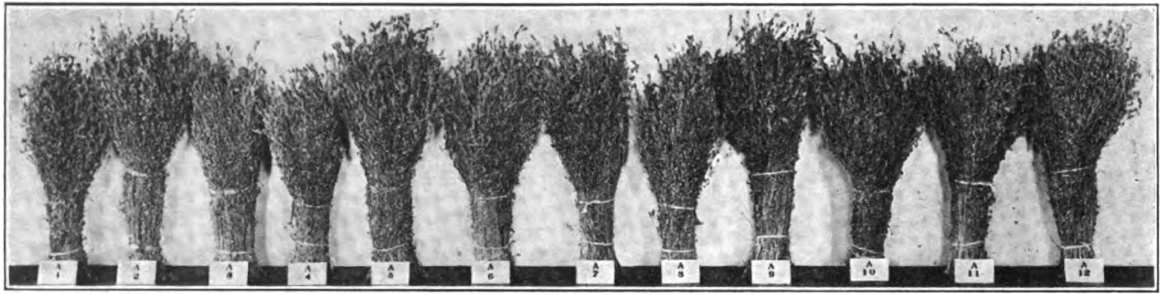
Depth of application, inches	*Total irrigation, inches*	*Total water content, per cent*	*Nitrogen, per cent*	*Proportion of leaves, per cent*	*Yield per acre, tons*	*Yield per acre-foot of water, tons*
Irrigated Before Plants Showed Need of Water						
6	66	84.2	3.04	36.45	6.00	1.21
9	65	86.0	3.30	35.91	5.81	1.18
12	81	81.4	3.32	37.38	6.18	1.03
Irrigated When Plants Showed Need of Water by Dark-Green Color of Foliage						
6	42	78.6	3.38	40.20	5.59	1.67
9	45	81.2	3.55	40.54	5.45	1.61
12	54	77.8	3.99	38.49	5.43	1.57
Irrigated When Plants Showed Need of Water by Dark-Green Color of Foliage and Drooping Leaves						
6	22	78.8	3.45	44.27	4.08	2.23
9	32	77.5	3.79	41.46	4.42	1.78
12	33	72.8	3.16	38.55	4.86	1.93

In the average results of the first three plats which were irrigated before plants showed need of water, a total irrigation of 70 inches produced 5.99 tons of alfalfa per acre; and of the second stage of wilting, a total irrigation of 47 inches produced 5.49 tons per acre. The average increase in yield of 0.5 tons per acre was secured by an additional use of 23 inches, which was at the rate of 0.25 tons per acre-foot of water. In the last stage of wilting an average total irrigation of 29 inches produced a yield of 4.45 tons per acre. The above results indicate that alfalfa cannot be allowed to reach the wilting point without seriously lowering its production, but that good returns may be secured when water is withheld until the plants turn dark-green in color.

Most Economical Depth of Irrigation.

The most economical use of water with alfalfa was accomplished with a total irrigation of 3.5 feet applied when plants showed need of water by dark-green color of foliage, producing 5.59 tons per acre, or at the rate of 1.67 tons per acre-foot of water. The use on this plat was equivalent during the period of irrigation to a delivery of water at the rate of one second-foot for 85 acres, or 0.47 miner's inch per acre.

The greatest total irrigation of 81 inches of water was accompanied



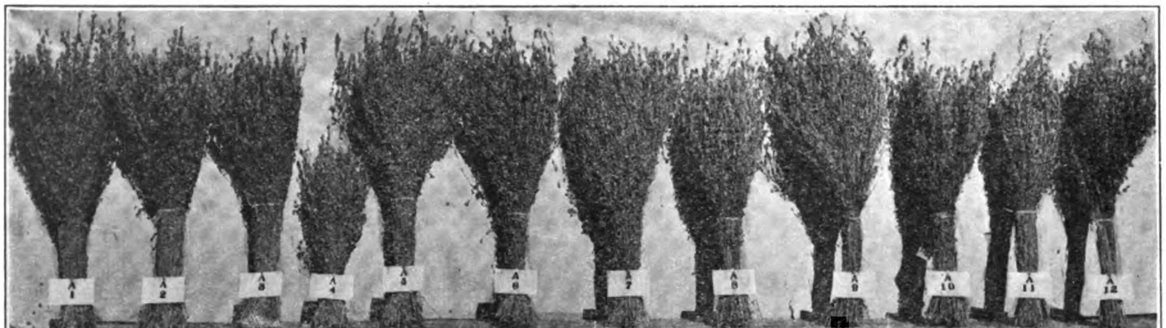


Plate 10—Variation in height of alfalfa with different methods of irrigation. Above, first crop; below, second crop. Plats 2, 5, and 9, irrigated before plants were allowed to show need for water, with *-, 9-, and 12-inch applications, respectively. Plats 3, 6, and 10, irrigated when plants showed need of water by dark-green color of foliage, with 6-, 9-, and 12-inch applications, respectively. Plats 4, 8, and 11, irrigated when plants showed need of water by dark-green color of foliage and drooping leaves, with 6-, 9-, and 12-inch applications, respectively.

by the highest yield of 6.18 tons of alfalfa per acre and the lowest yield of 1.03 tons per acre-foot of water. Compared with the yield of 5.59 tons per acre the increase of 0.6 ton was obtained at the expense of an additional use of 39 inches of water which was at the rate of 0.18 ton per acre-foot. The lowest total irrigation of 22 inches gave the highest yield of 2.23 tons per acre-foot of water, but the lowest yield of 4.08 tons per acre.

Relation of Soil Moisture Content to Time and Amount of Irrigation.

Soil moisture samples were taken before the first irrigation and at harvest of the second crop. The samples were taken to a depth of four

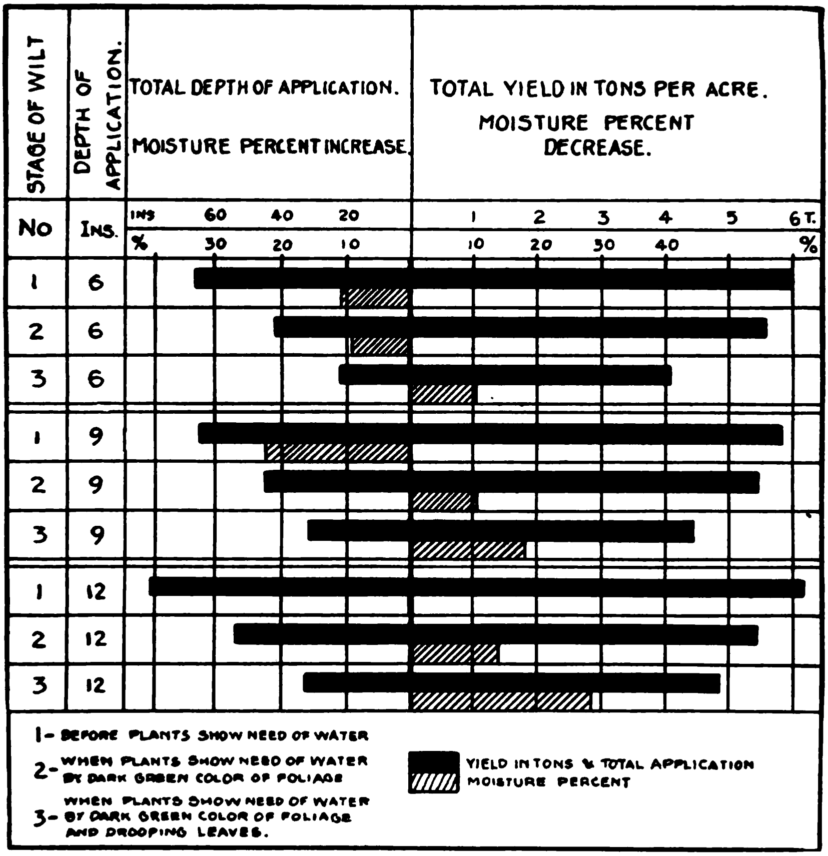


Plate 11—Irrigation of Alfalfa. Average results for the four-year period, 1915–1918, showing effect of irrigation on soil moisture.

feet and the borings from three different places on each plat were consolidated to insure a representative sample. During the year 1918 samples were taken before and after each irrigation in the manner above indicated. Experiments were also conducted to determine the weight per cubic foot and water-holding capacity of the surface foot in each plat. The following table compares the soil moisture contents before the first irrigation and before the second cutting of alfalfa at different stages of wilting, with six-, nine-, and twelve-inch applications.

IRRIGATION OF ALFALFA

Comparing the Per Cent of Decrease in Soil Moisture Content Before Harvest and Before the First Irrigation for the Four-Year Period, 1915–1918

	Before plants showed need of water, per cent	When plants showed need of water by dark-green color of foliage, per cent	When plants showed need of water by dark-green color of foliage and drooping leaves, per cent
Six-inch Applications—			
Total Irrigation, inches	66.00	42.00	22.00
Yield per acre, tons	6.00	5.59	4.08
Yield per acre-foot of water, tons	1.21	1.67	2.23
Average per cent of decrease in soil moisture at harvest	10.70*	9.10*	10.60*
Nine-inch Applications—			
Total irrigation, inches	65.00	45.00	32.00
Yield per acre, tons	5.81	5.45	4.42
Yield per acre-foot of water, tons	1.18	1.61	1.78
Average per cent of decrease in soil moisture at harvest	22.10*	10.40	18.30
Twelve-inch Applications—			
Total irrigation, inches	81.00	54.00	33.00
Yield per acre, tons	6.18	5.43	4.86
Yield per acre-foot of water, tons	1.03	1.57	1.93
Average per cent of decrease in soil moisture at harvest	0.00	14.00	28.20

*Average per cent of increase in soil moisture content at harvest.

An increase in soil moisture content at harvest is noted with six-inch applications in the first two stages of wilting and with nine-inch applications in the first stage, due in part to the frequency of irrigation. The greatest increase of 22.1 per cent is noted in the first stage of wilting with nine-inch applications and a total irrigation of sixty-five inches.

The most uniform decrease in moisture content at harvest is noted in the third or last stage of wilting. Here the total irrigation and yield per acre increase as the decrease in moisture content at harvest and the depth of application become greater. Generally the decrease in soil moisture content at harvest was greatest with the nine- and twelve-inch applications.

During the season of 1918 soil moisture determinations were made just before and within forty-eight hours after each irrigation, to determine the amount of water actually retained in the first four feet of soil, the results of which are given in the following table:

IRRIGATION OF ALFALFA

Average Soil Moisture Content Before and After Irrigation in 1918

Depth of irrigation inches	Soil moisture content: Before irrigation, per cent	Soil moisture content: After irrigation, per cent	Increase, per cent	Amount of irrigation retained in upper 4 feet: Inches	Amount of irrigation retained in upper 4 feet: Per cent
Irrigated Before Plants Showed Need of Water					
6	12.6	16.8	4.2	3.00	50.0
9	15.6	19.3	3.7	2.52	28.0
12	14.2	18.4	4.2	3.00	25.0
Irrigated When Plants Showed Need of Water by Dark-Green Color of Foliage					
6	11.1	17.0	5.9	4.20	70.0
9	11.7	18.2	6.5	4.60	51.0
12	12.7	18.4	5.7	4.05	33.7
Irrigated When Plants Showed Need of Water by Dark-Green Color of Foliage and Drooping Leaves					
6	10.3	16.1	6.3	4.55	75.8
9	9.7	16.8	7.1	5.09	56.0
12	9.4	17.0	7.6	5.40	45.0

This table gives the results of work for one year only, which cannot be considered as conclusive; however, they bear out the statements previously made. When alfalfa was irrigated before the plants showed need of water, about three inches of water of each application were held in the first four feet of soil. This amounts to one-half of a six-inch, one-third of a nine-inch, and one-fourth of a twelve-inch irrigation, the remainder of the water being lost by evaporation or percolation beyond the root zone.

The total amounts of water held in the soil were greatest with the last two stages of wilting. In each case a larger part of the six-inch application was retained than of the nine- or twelve-inch applications.

The high percentage of the six-inch irrigation retained in the second stage of wilting, or when plants showed need of water by dark-green color of foliage, accompanied by the high yield per acre and yield per acre-foot of water, indicates that this was the most economical use of water with alfalfa.

IRRIGATION OF WHEAT

The irrigation experiment with wheat was conducted during the five-year period, 1914–1918, and included sixty plats, each 22 feet wide by

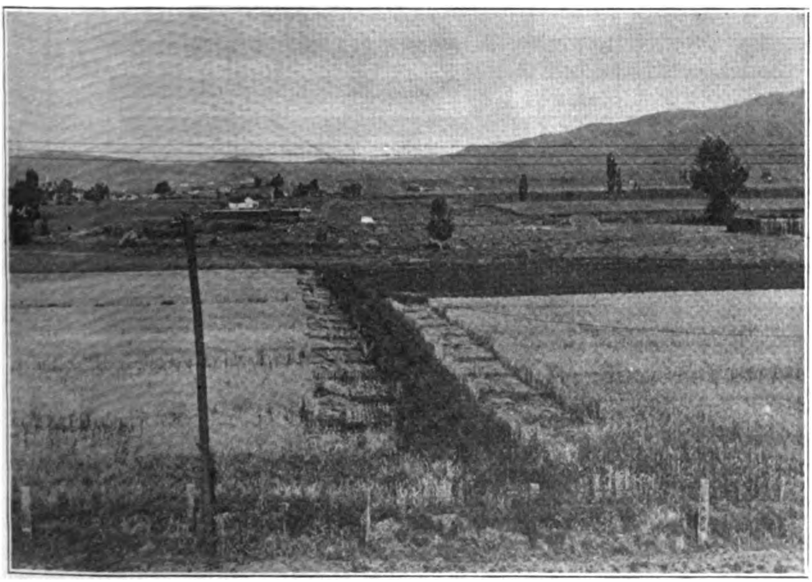


Plate 12—Irrigation of Wheat. Trimming the plats before harvest.

165 feet long. The plats were separated by levees four feet wide and high enough to prevent any overflow from one plat to another. Marquis wheat, used in this experiment, was treated each year for smut, and sown during the early part of April about two inches deep with a double-disk drill, using approximately seventy-five pounds of seed per acre. The wheat was irrigated by means of furrows placed at intervals of three feet. The water was measured into each plat through three pipes, one hour and seven minutes being required for a three-inch application, and a proportionate increase in time for the larger applications. Every third plat was a check.

Three-, five-, and seven-inch applications were given at the following stages of growth:

1. Five-leaf.
2. Boot.
3. Bloom.
4. Milk.
5. Dough.

Also six-, nine- and twelve-inch applications were given before and after heading.

In this test a comparison was made of the plats receiving an irrigation at each of the five stages of growth; with plats in which an irrigation was omitted at each of the five stages; with plats in which irrigations

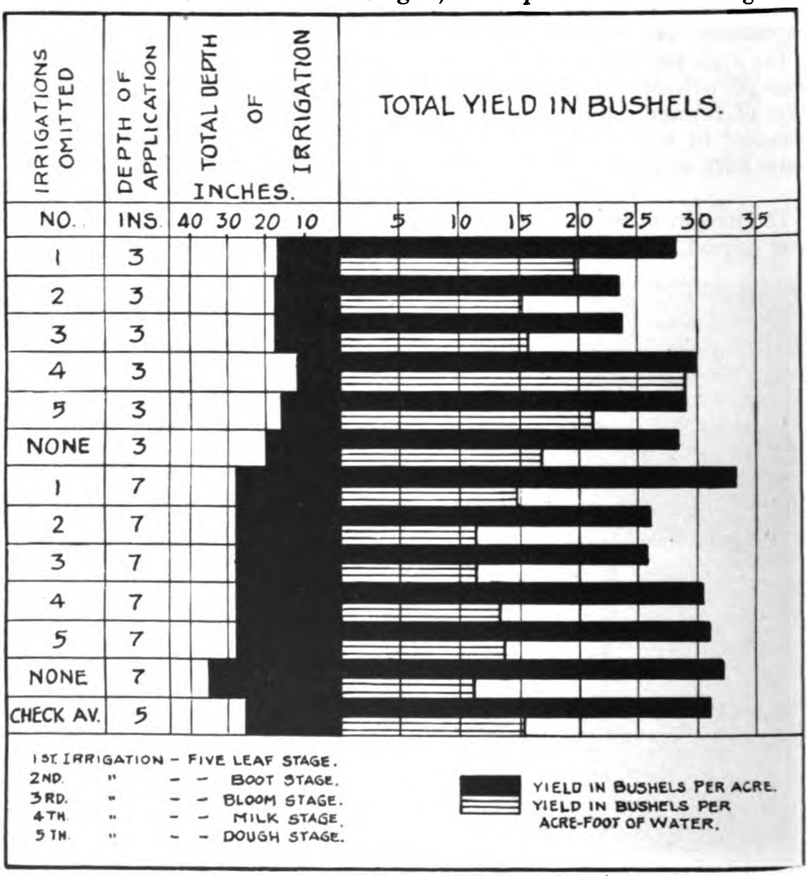


Plate 13—Irrigation of Wheat. Average results with four applications, for the five-year period, 1914–1918, showing effect of irrigation on yield per acre and yield per acre-foot of water.

were omitted at any two stages of growth; and with plats that received the same amounts of water in two applications only, one before and one after heading. The principal objects of the experiment were to determine the best depths of irrigation and the critical stages in the growth of the wheat crop.

The wheat plats were harvested in early August with a grain binder. The plats that received only three applications with a small total irrigation were the first to reach maturity. The wheat was threshed with

a small thresher operated by a six-horsepower gasoline engine. This machine made possible the thorough cleaning of the wheat with practically no loss in threshing.

Results with Four Applications.

The following table gives the results with three- and seven-inch applications when one irrigation was omitted at each of the different stages of growth, and the increase of seven-inch over the three-inch applications:

IRRIGATION OF WHEAT

Average Yields for the Five-Year Period, 1914–1918

One irrigation omitted at—	*Three-inch applications, bushels*	*Seven-inch applications, bushels*	*Average increase, per cent*
Five-leaf stage	28.1	33.3	18.5
Boot stage	23.4	26.2	11.9
Bloom stage	23.7	25.9	9.3
Milk stage	29.8	30.4	2.1
Dough stage	29.1	31.0	6.5
No irrigation omitted	28.4	32.2	13.4

These results are in favor of the seven-inch applications, the highest yield being obtained when an irrigation was omitted at the five-leaf stage. This yield of 33.3 bushels, is 18.5 per cent higher than the corresponding yield with three-inch applications, and four per cent greater than the yield of 32.2 bushels when no irrigations were omitted and a total of thirty-five inches of water was applied. With both three- and seven-inch applications the lowest yields are recorded when an irrigation was omitted at the boot or bloom stage. The results indicate that an irrigation may be omitted at the five-leaf, milk or dough stage without materially decreasing the yield of grain, but that an application omitted at the boot or bloom stage seriously interferes with the proper growth of the crop. The high yield of 33.3 bushels may be attributed to the greater development of root system with the first irrigation omitted and at the same time the plants did not suffer for lack of sufficient moisture before the irrigation at the boot stage.

Results with Three Applications.

The following table gives the average results with three- and seven-inch applications and with two irrigations omitted at the different stages of growth:

IRRIGATION OF WHEAT

Average Yields for the Five-Year Period, 1914–1918

Two irrigations omitted at—	*Three-inch applications, bushels*	*Seven-inch applications, bushels*	*Average increase, per cent*
Five-leaf and boot	15.9	20.4	28.3
Five-leaf and bloom	21.2	23.9	12.7
Five-leaf and milk	27.1	28.2	4.1
Five-leaf and dough	27.6	31.0	12.3
Boot and bloom	13.8	19.5	41.3
Boot and milk	21.2	23.5	10.8
Bloom and milk	23.2	23.8	2.6
Bloom and dough	24.8	28.8	16.1
Milk and dough	29.0	30.5	5.2
No irrigations omitted	28.4	32.2	13.4

The results here are also in favor of the seven-inch applications, although the variation in yield was more pronounced, especially between the three-inch and seven-inch applications. The highest yield was

obtained with seven-inch applications when irrigations were omitted at the five-leaf and dough stages. However, this yield of 31.0 bushels was but slightly greater than the yield of 30.5 bushels obtained when applications were omitted at the milk and dough stages. The highest yield was four per cent lower than when no applications were omitted. The

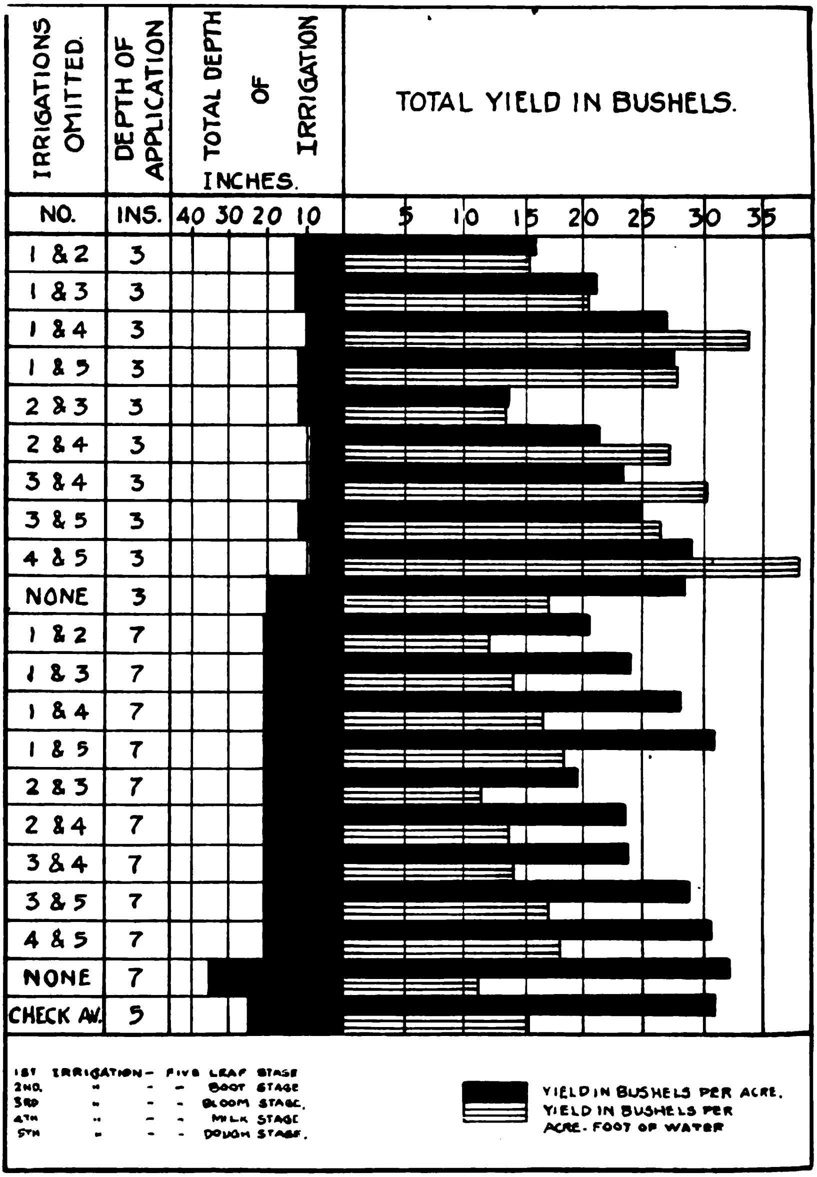


Plate 14—Irrigation of Wheat. Average results with three applications, for the five-year period, 1914–1918, showing effect of irrigation on yield per acre and yield per acre-foot of water.

lowest yield of 19.5 bushels with seven-inch applications was obtained with irrigations omitted at the boot and bloom stages.

With three-inch applications the highest yield was obtained when irrigations were omitted at the milk and dough periods. High yields were also obtained when irrigations were omitted at the five-leaf and milk and five-leaf and dough stages. The lowest yield was obtained when applications were omitted at the boot and bloom periods, the yield in this case being 53 per cent lower than the highest yield with three-inch applications. The other low yields correspond generally to the low yields with seven-inch applications.

The high yields obtained with seven-inch applications when irrigations were omitted at the five-leaf and milk, five-leaf and dough, and milk and dough stages indicate that irrigations omitted at any two of these stages have the least effect in lowering the yield of wheat.

The low yields with both three-inch and seven-inch applications when irrigations were omitted at the boot and bloom stages indicate that a very critical period in the irrigation of wheat is between the boot and the milk stages.

Yield Per Acre-Foot of Water with Three and Four Irrigations and Three- and Seven-Inch Applications.

The following table gives a comparison of the yields per acre and yield per acre-foot of water with three and four irrigations and three- and seven-inch applications:

IRRIGATION OF WHEAT

Average Results for the Five-Year Period, 1914–1918

	Three-inch applications			*Seven-inch applications*		
	Total irrigation, inches	*Yield per acre, bushels*	*Yield per acre-foot of water, bushels*	*Total irrigation, inches*	*Yield per acre, bushels*	*Yield per acre-foot of water, bushels*
One irrigation omitted at—						
Five-leaf stage	17	28.1	19.6	28	33.3	14.8
Boot stage	18	23.4	15.1	28	26.2	11.7
Bloom stage	18	23.7	15.8	28	25.9	11.4
Milk stage	12	29.8	29.1	28	30.4	13.4
Dough stage	16	29.1	21.3	28	31.0	13.8
No irrigations omitted	21	28.4	16.9	35	33.2	11.2
Two irrigations omitted at—						
Five-leaf and boot	13	15.9	15.3	21	20.4	12.1
Five-leaf and bloom	13	21.2	20.5	21	23.9	14.1
Five-leaf and milk	10	27.1	33.7	21	28.2	16.5
Five-leaf and dough	12	27.6	27.9	21	31.0	18.3
Boot and bloom	12	13.8	13.5	21	19.5	11.5
Boot and milk	9	21.2	27.3	21	23.5	13.8
Bloom and milk	9	23.2	30.3	21	23.8	14.0
Bloom and dough	12	24.8	26.4	21	28.8	16.9
Milk and dough	9	29.0	38.3	21	30.5	17.9
Average of checks				25	31.0	15.3

NOTE—Where a three-inch application failed to irrigate the entire plat, sufficient additional water was applied, accounting for the slight irregularity shown in the average total irrigation.

With a total irrigation of 28 inches of water given in four applications and an irrigation omitted at the five-leaf stage, the highest yield of 33.3 bushels per acre was accompanied by the highest yield of 14.8 bushels per acre-foot of water.

With seven-inch applications the highest yield of 18.3 bushels per acre-foot of water with a total irrigation of 21 inches was produced

where irrigations were omitted at the five-leaf and dough stages and the lowest yield of 11.1 bushels per acre-foot of water with a total irrigation of 35 inches. With three-inch applications the greatest yield of 38.3 bushels per acre-foot of water was obtained with irrigations omitted at the milk and dough stages, and the lowest yield of 13.5 bushels per acre-foot of water with irrigations omitted at the boot and bloom stages.

Results with Two Irrigations.

The following table compares the yields of wheat per acre and yields per acre-foot of water where only two irrigations were given and different depths of applications used before and after heading:

IRRIGATION OF WHEAT

Average Results for the Five-Year Period, 1914–1918

Depth of irrigation			
Before heading, inches	*After heading, inches*	*Yield per acre, bushels*	*Yield per acre-foot of water, bushels*
6	6	26.5	26.5
6	9	25.7	20.6
6	12	25.8	17.1
9	6	23.5	18.8
9	9	29.1	19.3
9	12	26.0	14.9
12	6	25.1	16.7
12	9	25.3	14.5
12	12	26.4	13.2

Where only two irrigations were given, the two nine-inch applications, one before and one after heading, produced the greatest yield of 29.1 bushels per acre, or 14.4 per cent less than the highest yield with 28 inches of water in four seven-inch applications. The twelve-inch irrigation before heading apparently provided more water than the crop utilized to best advantage. The maximum yield with two irrigations was obtained with a total of 18 inches of water applied when the crop turned dark green in color. With a total irrigation of less than 18 inches the yield was considerably decreased; whereas, a total irrigation of twenty-four inches in two twelve-inch applications produced an average of 26.4 bushels per acre or about ten per cent less than where the two nine-inch applications were used.

Yield Per Acre-Foot of Water with Two Irrigations.

The highest yield of 26.5 bushels per acre-foot of water was obtained with the smallest total irrigation of twelve inches, and the lowest yield of 13.2 bushels per acre-foot of water with the largest total irrigation of 24 inches. The third highest yield of 19.3 bushels per acre-foot of water was produced with the two nine-inch applications, indicating that this was the most economical use of water with wheat when only two applications were given.

With only two irrigations the yields were generally lower throughout than with a greater number of applications using the same total amount of water. It is therefore recommended that only in cases of water shortage is it advisable to use only two irrigations in preference to three or four applications, as shown in the results of these experiments where the yields of grain are generally much higher. It should be noted, however, that with only two irrigations possible, a profitable crop of wheat may be grown.

Relation of Soil Moisture Content to Time and Amount of Irrigation.

Soil moisture samples were taken at regular intervals each year during the period of irrigation to determine the variation in moisture content in relation to the time of irrigation and the depth of application.

Soil Moisture Contents with One Irrigation Omitted.

The following table gives a comparison of the soil moisture contents before the first irrigation and at harvest with three-inch and seven-inch applications and one irrigation omitted.

IRRIGATION OF WHEAT

Average Per Cent of Decrease in Soil Moisture Content at Harvest for the Five-Year Period, 1914–1918

	Three-inch applications		Seven-inch applications	
Irrigation omitted at—	Decrease, per cent	Yield per acre, bushels	Decrease, per cent	Yield per acre, bushels
None	11.0	28.4	6.8	32.2
Five-leaf stage	19.0	28.1	0.5*	33.3
Boot stage	17.2	23.4	2.4*	26.2
Bloom stage	0.5	23.7	9.9*	25.9
Milk stage	8.3	29.8	2.7*	30.4
Dough stage	26.6	29.1	14.4	31.0

*Average per cent of increase of soil moisture content at harvest.

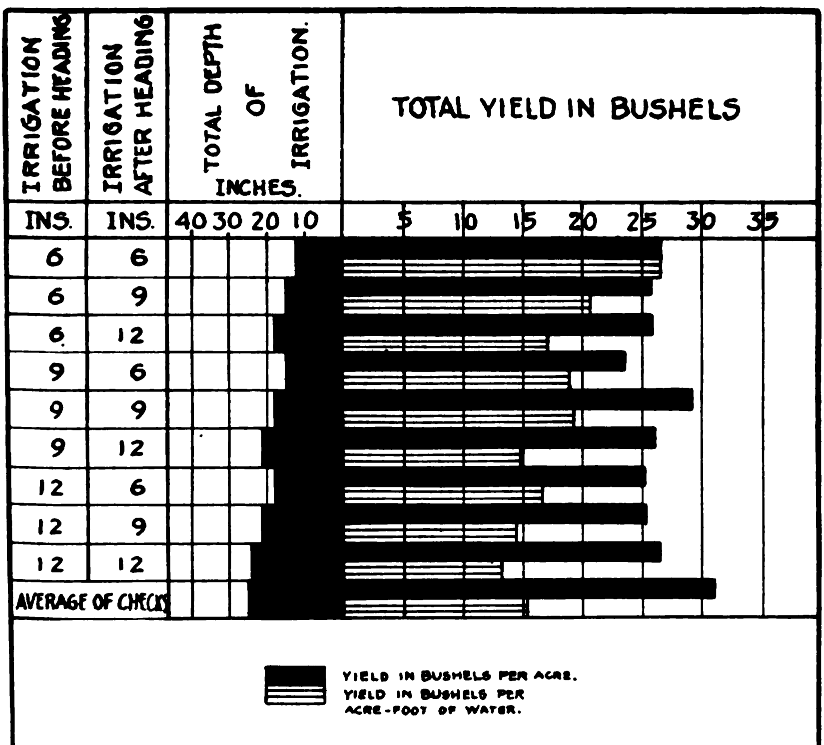


Plate 15—Irrigation of Wheat. Average results with two applications for five-year period, 1914–1918, showing effect of irrigation on yield per acre and yield per acre-foot of water.

These results show that the high yields per acre are generally accom-

panied by the greatest decrease in soil moisture at harvest as compared with the soil moisture content before the first irrigation. With three-inch applications the smallest decrease in soil moisture content at harvest, with an irrigation omitted at the bloom stage, was accompanied by the low yield of 23.7 bushels per acre, or 23 per cent less than the yield with one irrigation omitted at the dough stage.

With seven-inch applications the greatest increase in soil moisture content at harvest was obtained when an irrigation was omitted at the bloom stage, the yield being 25.9 bushels per acre, or 20 per cent less than the highest yield.

The omission of an irrigation at the bloom stage seriously checked the development of the wheat crop and prevented the plants from utilizing the moisture in the soil to the best advantage during the later periods of growth.

Soil Moisture Contents with Two Irrigations Omitted.

The following table gives a comparison of soil moisture contents before the first irrigation and at harvest with three-inch and seven-inch applications, and with two irrigations omitted:

IRRIGATION OF WHEAT

Average Per Cent of Decrease in Soil Moisture Content at Harvest for the Five-Year Period, 1914–1918

	Three-inch applications		*Seven-inch applications*	
Two irrigations omitted—	*Decrease, per cent*	*Yield per acre, bushels*	*Decrease, per cent*	*Yield per acre, bushels*
Five-leaf and boot	13.2	15.9	2.5	20.4
Five-leaf and bloom	2.1	21.2	10.1*	23.9
Five-leaf and milk	17.4	27.1	4.8	28.2
Five-leaf and dough	9.5	27.6	4.7	31.0
Boot and bloom	1.5	13.8	0.0	19.5
Boot and milk	9.5	21.2	7.3	23.5
Bloom and milk	15.2	23.2	6.4*	23.8
Bloom and dough	19.6	24.8	0.0	28.8
Milk and dough	24.9	29.0	11.7	30.5

*Average per cent of increase in soil moisture content at harvest.

It is noted in these results that with the three-inch applications the smallest decrease in soil moisture content at harvest was obtained with irrigations omitted at the boot and bloom stages, and accompanied by the lowest yield of 13.8 bushels per acre. The next lowest decrease in soil moisture content at harvest occurred with irrigations omitted at the five-leaf and bloom stages, accompanied by a comparatively low yield of 21.2 bushels per acre.

With the seven-inch applications it is interesting to note that where no decrease or where an increase is shown in the soil moisture content at harvest, one of the irrigations omitted in each instance was at the bloom stage. The average yield of these four plats was 24.0 bushels per acre, or 29.2 per cent less than the highest yield with one irrigation omitted at the five-leaf stage. This confirms the previous statement that an irrigation omitted between the boot and milk stages may seriously check the proper development of the crop.

IRRIGATION OF POTATOES

The irrigation experiment with potatoes included nineteen plats of four rows each. The potatoes were planted the last of May each year in rows three feet apart and about fourteen inches apart in the row. The potatoes were irrigated by means of comparatively deep furrows

three feet apart. Three-, six-, and nine-inch applications of water were at the following stages of growth:

1. Before plants showed a tendency to wilt.
2. When plants showed a tendency to wilt.
3. When leaves wilted down once.
4. When plants failed to revive at night.

The crop was harvested each year about the first of October. Of the four rows in each plat the two outside rows were eliminated to prevent as far as possible any variation due to seepage from adjoining plats. Three hills in different parts of each plat were selected for a determination of the starch content.[1]

Plate 16—Irrigating a field of Nevada potatoes.

The following table gives the average results on total irrigation, water content, starch content, yield per acre and yield per acre-foot of water:

IRRIGATION OF POTATOES

Average Results for the Four-Year Period, 1914–1917

Depth of irrigation, inches	*Total irrigation, inches*	*Water content, per cent*	*Starch content, per cent*	*Yield per acre, pounds*	*Yield per acre-foot of water, pounds*
		Irrigated before plants were allowed to wilt			
3	22.5	76.7	68.3	15,333	8,622
6	28.5	76.4	65.4	10,577	4,530
9	38.2	77.3	68.3	13,402	4,239
		Irrigated when plants showed a tendency to wilt			
3	16.5	78.4	64.4	15,977	12,025
6	19.5	77.3	63.2	9,597	5,730
9	27.0	77.2	65.2	9,175	6,593
		Irrigated when plants wilted down once			
3	10.5	78.4	56.2	9,665	14,036
6	13.5	78.5	62.4	9,849	9,172
9	18.0	76.1	64.8	7,786	6,819

[1] The starch content was determined by means of direct acid hydrolosis. See page 53, Bulletin 107, Bureau of Chemistry, U. S. Department of Agriculture.

	Irrigated when plants failed to revive at night				
3	6.0	78.7	59.3	5,825	11,958
6	7.5	78.4	58.8	5,525	10,571
9	9.0	78.6	59.8	3,593	4,464
Average of checks—					
6	24.0	76.8	66.9	9,753	4,858

The yield of potatoes in 1915 was materially decreased by dry rot, and in 1916 by an unfavorable season. However, all plats appeared to be equally affected; thus the comparative results are about as valuable as with greater production. The results showed that with the three-, six-, and nine-inch applications, the average total irrigation, the starch

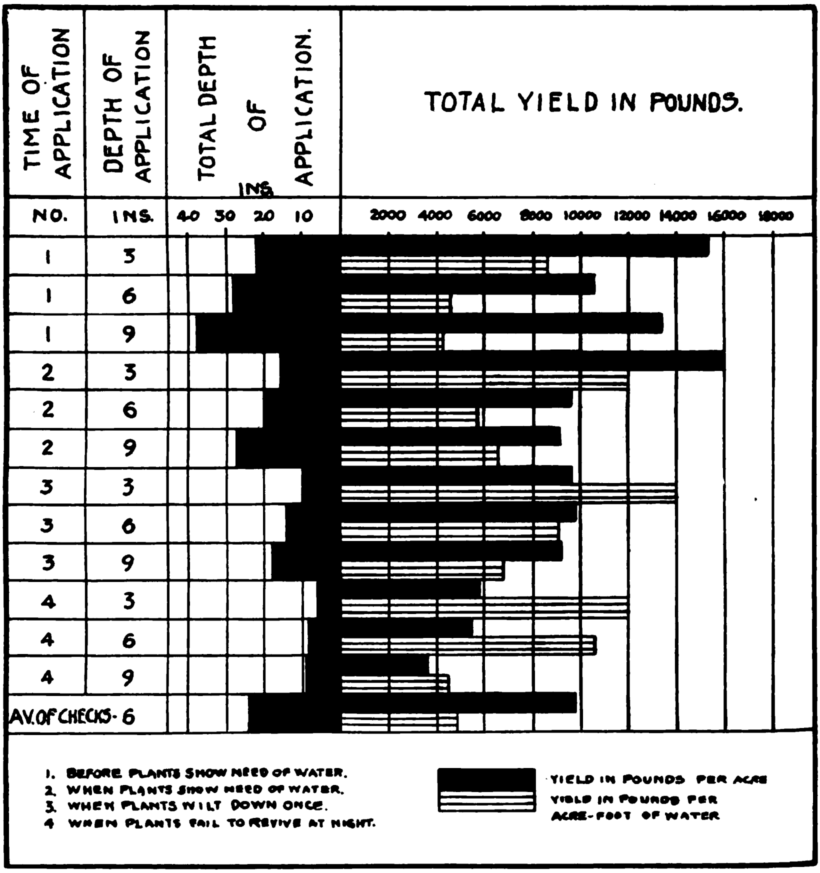


Plate 17—Irrigation of Potatoes. Average results for the four-year period, 1914–1917, showing the effect of irrigation on yield and yield per acre-foot of water.

content, and the yield per acre decreased with the advance in the wilting stage, while the yield per acre-foot of water increased, except in the last wilting stage, where a considerable decrease is noted with nine-inch applications.

The best average results were generally obtained with the three-inch applications at the different stages of wilting. For the four-year period,

the highest yield of 15,977 pounds per acre was obtained with an average total irrigation of 16.5 inches with three-inch applications given when the plants showed a tendency to wilt, and the yield per acre-foot of water was 12,025 pounds. The next best yield of 15,333 pounds per acre was secured with eight three-inch applications given before plants showed a tendency to wilt, although the yield per acre-foot of water was only 8,622 pounds per acre. Where the plants wilted down before irrigation, the potatoes made a second growth which resulted in lowering the yield per acre and starch content of the potatoes. The proportion of scabby potatoes was greatly increased in those plats which received a total irrigation of twenty-four inches or more of water.

General Statement.

The potato rows should be hilled up with good deep furrows between them, so that, when irrigated, the water will supply the deep-feeding roots, but will not come in contact with the tubers.

A too common error with the potato grower is the use of shallow furrows for carrying the water. The chief danger is in saturating the ground around the tubers, causing the soil to become hard and compact, a very undesirable condition for the development of a good hill of uniform potatoes. It is thus very important to use light irrigations in good deep furrows.

The potato crop should never be irrigated by means of flooding,

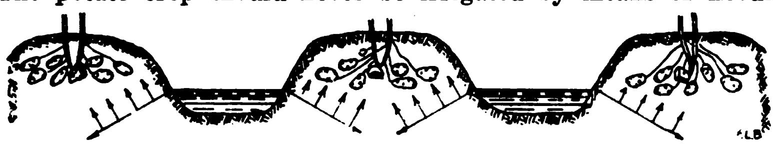


Plate 18—The proper method of irrigation for potatoes.

since this method causes the soil to pack around the tubers and prevents the ground from receiving sufficient water for the need of the plants.

The potato crop is very sensitive to an excess of moisture in the soil. Most of the failures in potato growing in this State have occurred on the heavy lands and have been due chiefly to this one cause. Soils which contain an excess of water are too cold for the proper development of the potato and offer conditions favorable to the formation of scab and rot. Most of the soils on the Experiment Station Farm are too heavy and too level for good results with potatoes. It is noted above that the most practical method of irrigation was by the use of light applications when the plants had turned dark-green in color. At the time of harvest this ground turns up in large clods unless irrigated immediately before digging. This condition indicates that the ground has packed too firmly for the proper development of uniform marketable potatoes. Such lands are made more porous by a heavy application of lime of gypsum, but the potatoes are liable to be badly affected with scab, as is the case when fresh manure is used in large quantities. Many growers overcome this objection on heavy soils by planting the potatoes on land with a considerable slope. Here the drainage is good and there is less danger that the soil will remain too wet.

For the best results with potato growing, well-drained land is essential, and only moderate applications of water should be given the crop when needed.

The following table gives a comparison of soil moisture content with

potatoes before the first irrigation and before harvest, at different stages of wilting, with three-, six-, and nine-inch applications:

IRRIGATION OF POTATOES

Average Per Cent of Decrease in Soil Moisture Content Before Harvest for the Four-Year Period, 1914–1917

Soil samples taken	*Three-inch applications*	*Six-inch applications*	*Nine-inch applications*
Irrigated before plants showed tendency to wilt			
Before first irrigation	20.6	19.8	19.0
Before harvest	19.5	18.9	19.8
Per cent decrease	5.3	4.5	4.2*
Irrigated when plants showed tendency to wilt			
Before first irrigation	18.7	20.5	18.6
Before harvest	18.0	18.1	17.8
Per cent decrease	3.7	11.7	4.3
Irrigated when leaves wilted down once			
Before first irrigation	18.8	16.9	19.8
Before harvest	17.6	17.2	16.6
Per cent decrease	6.5	1.8*	16.1
Irrigated when plants failed to revive at night			
Before first irrigation	19.3	18.9	18.4
Before harvest	16.5	15.1	16.9
Per cent decrease	14.5	20.1	8.2

*Average per cent of increase in soil moisture content at harvest.

With the three-inch irrigations at the different stages of wilting the soil moisture contents before harvest were slightly less than before the first irrigation. This decrease is most evident in the last stage of wilting with 14.5 per cent.

With the six-inch applications an increase is shown in the third stage of wilting, while in the other three stages the soil moisture content at harvest was less than before the first irrigation, amounting to a decrease of 20.1 per cent in the last stage of wilting.

With the nine-inch irrigations a decrease was shown in the last three stages of wilting, amounting to 16.1 per cent where irrigated when leaves wilted down once; while a slight increase occurred when irrigations were given before plants showed a tendency to wilt.

Where the heaviest yield of 15,977 pounds per acre was produced with a total irrigation of 17 inches of water in three-inch applications, given when the plants first showed a tendency to wilt, the soil moisture content before harvest was only 3.7 per cent less than before the first irrigation. This heavy yield was accompanied by the second highest yield of 12,025 pounds per acre-foot of water.

Where the lowest yield of 3,593 pounds per acre was produced with one nine-inch application at the last wilting stage, the soil moisture content at harvest was 8.2 per cent less than before the first irrigation. Moreover, the yield per acre-foot of water was only 4,464 pounds as compared with 12,025 pounds for the highest yield and 17 inches total irrigation.

No uniform variations occurred in soil moisture content with potatoes as were found with alfalfa in the various stages of wilting and with different depths of application.

IRRIGATION OF CLOVER

The irrigation experiment with clover (Common Red) in 1914 was conducted on a sandy clay soil with a gravelly subsoil, and included

twelve plats, each 10 feet wide and 264 feet long. The clover was planted in the spring of 1913 with a nurse crop of wheat, and produced one crop of hay that season after the wheat had been harvested. The plats were separated by levees four feet wide and high enough to prevent any overflow of water from one plat to another.

In the irrigation of clover, six-, nine-, and twelve-inch applications were given at the following stages of wilting:

1. Before plants showed need of water.
2. When plants showed need of water by dark-green color of foliage.
3. When plants showed need of water by dark-green color of foliage and drooping leaves.

During the season of 1914 two crops of hay were harvested on June 16, and August 5, respectively. Samples of hay were selected from each plat with the two cuttings for a determination of nitrogen content.[1]

The following table gives the depth of application, total irrigation, nitrogen content and yield per acre-foot of water:

IRRIGATION OF CLOVER—1914

Depth of application, inches	*Total irrigation, inches*	*Nitrogen content, per cent*	*Yield per acre, tons*	*Yield per acre-foot of water, tons*
Irrigated before plants showed need of water				
6	36	2.32	4.45	1.48
9	42	2.19	5.52	1.58
12	57	1.81	6.97	1.47
Irrigated when plants showed need of water by dark-green color of foliage				
6	24	2.29	3.58	1.79
9	36	2.32	3.51	1.17
12	36	2.13	4.08	1.36
Irrigated when plants showed need of water by dark-green color of foliage and drooping leaves				
6	24	2.56	2.71	1.35
9	36	2.28	3.16	1.05
12	36	2.11	3.38	1.13
Average of checks—				
6	36	2.32	4.49	1.50

Results.

The results show that clover cannot be allowed to reach the wilting stage without materially decreasing the yield of hay: also, that in these experiments applications of from nine to twelve inches given before the plants showed need of water gave the heaviest production of hay. However, where the total yield was greatest, the yield per acre-foot of water was low and the quality of hay inferior to that of other plats, due to the large proportion of coarse stems to leaves. The importance of the time of application of water is well illustrated in the results, since a gradual decrease in yield occurred in the different plats with the same applications of water, as the wilting stage advanced, before water was applied. Clover responded more readily to the heavy applications of water than any other crop.

The lowest nitrogen content is noted with the greatest total irrigation and the highest yield per acre. With this exception no uniform variation occurred in the nitrogen content.

[1]The nitrogen content was determined by the official method used by the Bureau of Chemistry, U. S. Department of Agriculture.

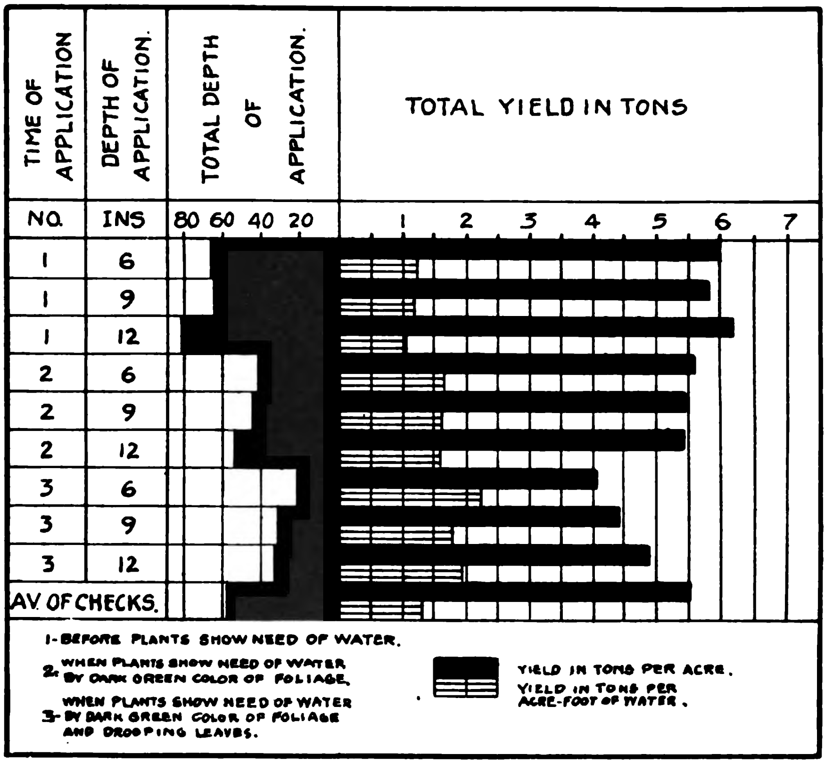


Plate 19—Irrigation of Clover. Average results 1914, showing effect of irrigation on yield per acre and piled per acre-foot of water.

SUGAR-BEETS

The irrigation experiment with sugar-beets during the two-year period, 1914–1915, included nineteen plats. Each plat consisted of four rows 165 feet long and two feet apart. The seed was planted with a hand drill, about one and one-half inches deep, at the rate of twenty pounds per acre.

In the irrigation of sugar-beets, two-, four-, and six-inch applications of water were given at the following stages of wilting:

1. Before plants showed a tendency to wilt.
2. When plants showed a tendency to wilt.
3. When leaves wilted down once.
4. When plants failed to revive at night.

When four leaves appeared on the plants, the beets were thinned to about ten inches apart in the rows. The crop received two hoeings when needed and was cultivated after each irrigation. The beets were harvested in late September with an ordinary walking beet-plow. Of the four rows in each plat, the two outside rows were eliminated as with potatoes. After plowing out the beets they were topped and weighed. Five average-sized beets from different parts of each plat were selected, weighed, and reserved for chemical analysis for sugar content and purity.[1] The following table compares the total irrigation,

[1]Sugar content and purity determined by means of indirect method. See Bulletin 146, page 14, Bureau of Chemistry, United States Department of Agriculture.

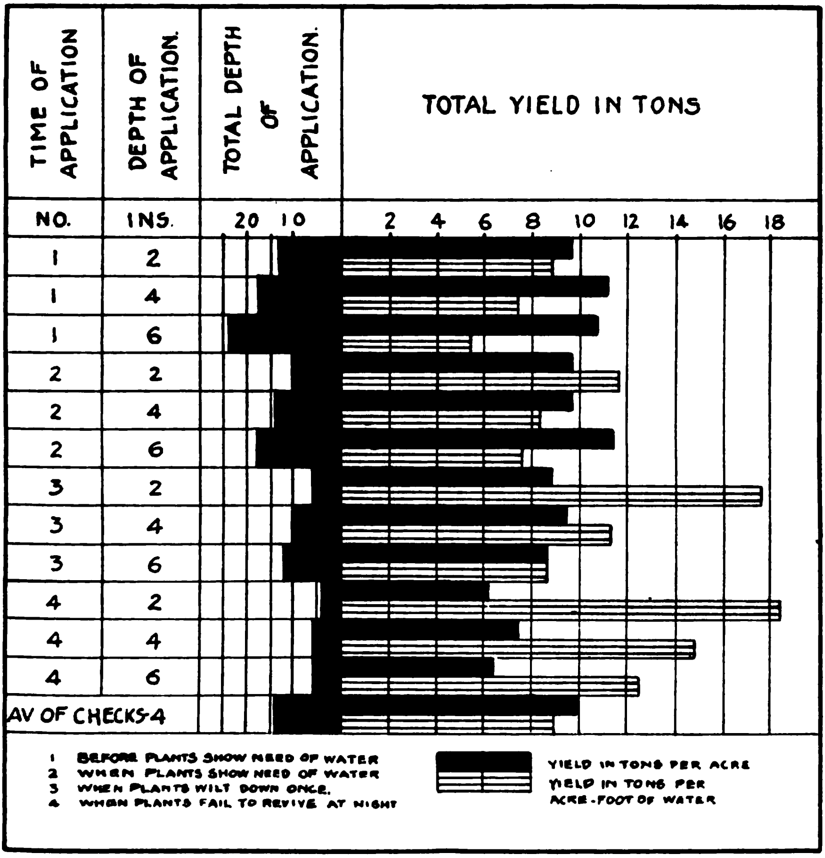


Plate 20—Irrigation of Sugar-Beets. Average results for the two-year period, 1914–1915, showing effect of irrigation on yield per acre and yield per acre-foot of water.

proportion of roots to tops, sugar content, purity, yield per acre, and yield per acre-foot of water at the different stages of wilting:

IRRIGATION OF SUGAR-BEETS

Average Results for the Two-Year Period, 1914–1915

Depth of application, inches	*Total irrigation, inches*	*Proportion of roots to tops, per cent*	*Sugar content, per cent*	*Purity of beet, per cent*	*Yield per acre, tons*	*Yield per acre-foot of water, tons*
		Irrigated before plants showed tendency to wilt				
2	13	76.1	21.95	86.29	9.58	8.84
4	18	72.9	20.92	81.57	11.31	7.37
6	24	74.9	21.18	82.52	10.70	5.35
		Irrigated when plants showed tendency to wilt				
2	10	74.1	22.91	87.34	9.64	11.58
4	14	74.0	21.48	87.12	9.67	8.30
6	18	69.5	20.60	82.20	11.43	7.62
		Irrigated when plants wilted down once				
2	6	72.0	23.39	76.61	8.80	17.60
4	10	71.2	21.01	84.48	9.40	11.28
6	12	67.8	22.61	83.02	8.57	8.57

Irrigated when plants failed to revive at night						
2	4	71.8	22.44	78.78	6.12	18.36
4	6	74.2	18.59	78.53	7.38	14.76
6	6	67.0	22.67	82.57	6.27	12.54

The average results for the two years show that the sugar-beets which were irrigated after they wilted down and failed to revive at night, did not produce a profitable crop. The greatest yield of 11.43 tons was obtained with three 6-inch applications given when the plants showed a tendency to wilt, and was accompanied by a relatively low yield of 7.62 tons per acre-foot of water. The lowest yield of 6.12 tons per acre was obtained in the last stage of wilting with two-inch applications, and was accompanied by the highest yield of 18.36 tons per acre-foot of water.

Only slight variations in yield are shown with the two-inch, four-inch, and six-inch applications, and also with the total irrigations of twelve, eighteen, and twenty-four inches. This is attributed partly to the lateral diffusion of moisture from one plat to another, since the plats were such a short distance apart. The sugar content of the beet was not materially affected by the stages of wilting or by the depth of application. The purity of juice in beets varied with the different stages of wilting, being greatest in the beets which received two- and four-inch applications where the plants showed a tendency to wilt. These plats produced an average of 9.65 tons of beets per acre. The error caused by this diffusion of water from one plat to another was so great that it was deemed advisable to discontinue this investigation after the two-year period.

SUMMARY

1. The approximate area of land in the State of Nevada is 70,285,440 acres, of which 900,000 acres, or 1.3 per cent, were irrigated in 1918.

2. In 1918, Nevada produced, approximately, 145,000 acres of alfalfa, 80,000 acres of wheat, and 15,000 acres of potatoes. These are the most important cultivated crops grown under irrigation.

3. Nevada lies almost wholly within the Great Basin. The Humboldt, Truckee, Carson, Walker and Muddy are the principal rivers supplying water for irrigation. More than 50 per cent of the irrigated area in the State received its water from the Humboldt River.

4. The greater portion of the aereage of alfalfa and grain in Nevada is irrigated by the border method of flooding. The furrow method is used in the irrigation of potatoes and other similarly cultivated crops.

5. The important factors affecting duty of water in Nevada are: Type of soil, topography, hardpan near the surface, annual rainfall and evaporation. The type of soil causes greater variation in the amount of water required under general field conditions than any other one factor.

6. The average results of early investigations on the irrigation of alfalfa at the Experiment Station, 1906–1911, show a total irrigation of 3.27 acre-feet of water, producing a yield of 5.93 tons per acre, or 1.87 tons per acre-foot of water.

7. During the five-year period of Irrigation Investigations, 1914–1918, practically no precipitation was received during the growing season that was sufficient to affect the moisture content of the soil. This is a unique condition which probably has not obtained in any other irrigated section of the West.

8. In the later investigations the water was measured into each plat through calibrated galvanized iron pipes two inches in diameter. Check plats were used to prevent, as far as possible, any errors due to variation in soil.

9. Alfalfa that was allowed to reach the wilting point before irrigation produced a relatively low yield per acre, but excellent returns were realized when irrigation was withheld until the plants turned dark green in color.

10. The most economical use of water with alfalfa was accomplished with a total irrigation of 3.5 feet applied when plants showed need of water by dark-green color of foliage, producing 5.59 tons per acre, or at the rate of 1.67 tons per acre-foot of water. Soil moisture determinations showed that 70 per cent of the six-inch applications was retained in the first four feet in depth of soil. The use on this plat was equivalent during the period of irrigation to a delivery of water at the rate of one second-foot for 85 acres, or 0.47 miner's inch per acre.

11. The highest yield of 6.18 tons per acre of alfalfa was obtained with 81 inches total depth when the crop was irrigated before plants showed need of water, but this was accompanied by the lowest yield of 1.03 tons per acre-foot. Compared with the yield of 5.59 tons per acre the increase of 0.6 ton was obtained at the expense of an additional use of 39 inches of water, which was at the rate of 0.18 ton per acre-foot. Soil moisture determinations showed that only 25 per cent of the twelve-inch applications was retained in the first four feet in depth of soil.

12. In the irrigation of alfalfa the decrease in soil moisture content at harvest was generally greatest with the nine- and twelve-inch applications. The total amounts of water held in the soil were greatest with the last two stages of wilting.

13. In the irrigation of wheat during the five-year period, 1914–1918, three- and seven-inch applications were given at two or more of the five stages of growth, including, five-leaf, boot, bloom, milk and dough stages.

14. The highest yield of wheat was obtained with 28 inches of water in four applications, when an irrigation was omitted at the five-leaf stage.

15. The highest yield of wheat with three irrigations occurred with 21 inches of water when applications were omitted at the five-leaf and dough stages.

16. The average yields of wheat were considerably higher with the seven-inch than with the three-inch applications.

17. The yields of wheat were relatively low when irrigations were omitted at the boot and bloom stages, thus indicating that a very critical period in the irrigation of wheat was between the boot and milk stages.

18. The highest yield of wheat with two irrigations was secured with nine-inch applications, one before and one after heading.

19. In the irrigation of wheat the high yields per acre were generally accompanied by the greatest decrease in soil moisture content at harvest as compared with the soil moisture content before the first irrigation.

20. In the irrigation of potatoes during the four-year period, 1914–1917, the highest yield was obtained with a total irrigation of 16.5 inches in three-inch applications, given when the plants showed a tendency to wilt.

21. In the irrigation of clover in 1914, a gradual decrease in yield occurred in the different plats with the same applications of water as the wilting stage advanced, before water was applied.

22. In the irrigation of sugar-beets during the two-year period, 1914–1915, the greatest yield was obtained with 18 inches of water in three-inch applications.

23. The results of these investigations on the irrigation of field crops, show that the most economical use of water was obtained with a total irrigation of 3.5 feet in six-inch applications for alfalfa and clover; 2.3 feet in seven-inch applications for wheat; and 1.5 feet in three-inch applications for potatoes and sugar-beets. When alfalfa fields are used for fall pasture, usually an additional irrigation is required after the last crop of hay is harvested.

CARSON CITY, NEVADA
STATE PRINTING OFFICE, : JOE FARNSWORTH, SUPERINTENDENT
1919

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Bulletin No. 97 August, 1919

DON'T FEED FOX-TAIL HAY TO LAMBING EWES!

By
C. E. FLEMING AND N. F. PETERSON
Of the Department of Range Management, Agricultural Experiment Station

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

1[48]

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

ACKNOWLEDGMENT

The Nevada Agricultural Experiment Station takes pleasure in thanking A. O. Larson of Castle Dale, Utah, for suggestions which led to the study of the poisonous properties of Arrow-Grass, and to Mr. G. W. Walts of Reno, Nevada, for valuable information and assistance.

ANNOUNCEMENT

In July, 1918, the Nevada Agricultural Experiment Station published Bulletin No. 95 entitled "Range Plants Poisonous to Sheep and Cattle in Nevada," by C. E. Fleming, head of the Department of Range Management. Hundreds of requests for copies were received from stockmen and forest rangers in Nevada and California. The Foreign Press Bureau of the Committee on Public Information requested 500 copies for distribution in South American countries. Although the number printed was unusually large, the entire edition of this bulletin was soon exhausted and republication has become desirable.

Since the publication of Bulletin No. 95 long series of feeding experiments with poisonous plants have been made at the Nevada Station. Before publishing another general bulletin on the subject of range plants poisonous to sheep and cattle it seems best to print a short series of bulletins giving the results of feeding tests made with each poisonous plant.

We plan later to bring together the results of all the new experiments with all former information on the subject in another illustrated general bulletin on poisonous plants.

S. B. DOTEN,
Director.

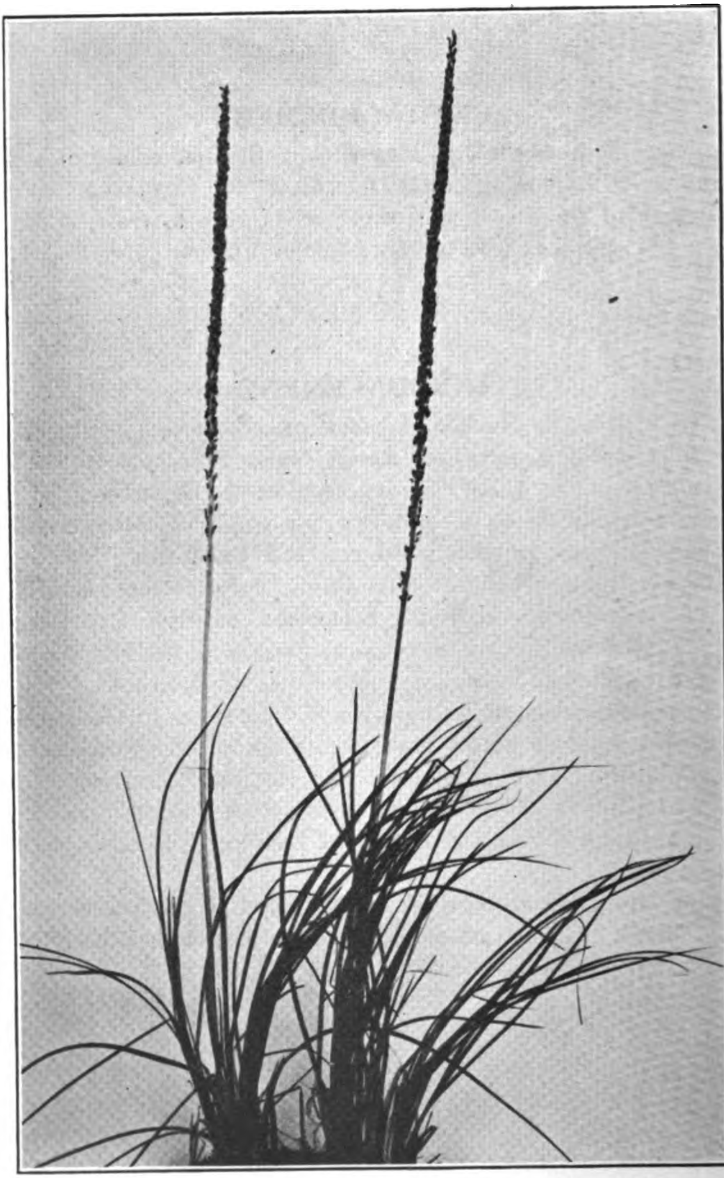


Figure 1. Typical plant of Arrow-Grass, showing cluster of leaves and two flower stalks.

Figure 2. Arrow-Grass, growing among other plants and grasses.

SUMMARY

1. Recent experiments conducted by the Agricultural Experiment Station of the University of Nevada show that under certain conditions the grasslike plant commonly known as Arrow-Grass is poisonous to both sheep and cattle.

2. Arrow-Grass looks like the common grasses; and often grows among them in wet soils especially where the ground contains alkali.

3. Figures 1, 2 and 3 of this bulletin give a good idea of the general appearance of the plant.

4. Arrow-grass contains an unknown substance, which is sometimes broken up in the stomach of the animal, liberating a deadly poison—hydrocyanic ("prussic") acid gas.

5. Animals fatally poisoned by Arrow-Grass breathe very rapidly at first; they tremble, breathe through the mouth, walk around stiffly, have spasms and go down in convulsions. Later they breathe more slowly and with increasing difficulty, spasms continuing at intervals until death, which occurs in from half an hour to three hours.

6. An animal must eat a large dose at one time in order to be poisoned. Small doses eaten at frequent intervals or moderate quantities eaten daily have no harmful effects.

7. Arrow-Grass cut and dried in hay is far more dangerous and deadly than the green plant.

8. When the body of an animal dead of Arrow-Grass poisoning is cut up there is little indication of the cause of death. There is usually some congestion of the lungs and of the fourth stomach, but neither condition is characteristic of this plant alone.

9. Because of the nature of the poison and because death follows poisoning so promptly, there is little hope of finding methods of treating and curing animals seriously poisoned by Arrow-Grass.

10. Places where Arrow-Grass grows very thickly should be fenced off. Considerable effort should be made to prevent Arrow-Grass from being cut, dried and put up in hay.

ARROW-GRASS

A New Stock-Poisoning Plant

(*Triglochin maritima*)

IN THE AUTUMN OF 1918 we were informed by A. O. Larson of Castle Dale, Utah, that cattle had died in southern Utah from eating a plant known in that region as "goose-grass." Fatal poisoning had been caused by the green plants in pastures and more especially by the dried plant in hay. Specimens sent by Mr. Larson to the Nevada Station were identified as "arrow-grass" or "sour-grass" (*Triglochin maritima*). The small amount of material sent from Utah was insufficient to produce any symptoms of poisoning in sheep; however, as this plant is common in wet and semialkaline places in the vicinity of Reno, experimental feedings of larger amounts were begun at once and continued throughout the spring and summer of 1919. These feeding tests showed clearly that under certain conditions the plant is poisonous to both sheep and cattle. The results of these tests are given in detail in this bulletin.

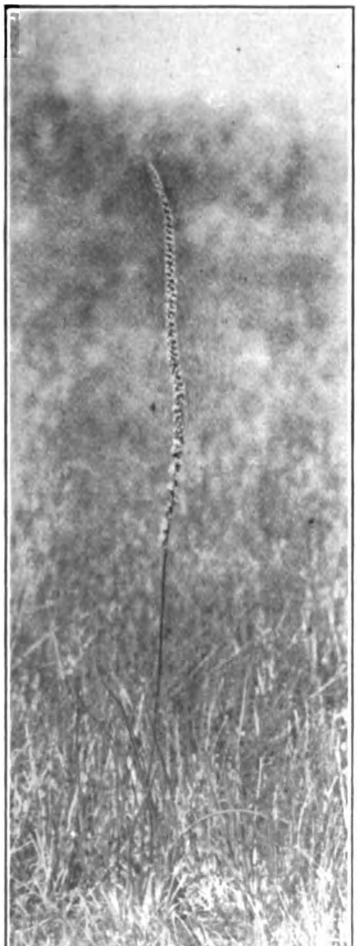


Figure 3. In grass meadows it is hard to find Arrow-Grass before it blooms.

Common Names.

Triglochin is known by three common names — arrow-grass, goose-grass, and sour-grass. Because arrow-grass is the name most commonly and universally used, its adoption and use by stockmen is recommended.

Description of Plant.

This poisonous plant belongs to a little family of plants known as the arrow-grass family. It grows in bright-green clumps and bunches, so much like grass that it is hard to find in the midst of grasses and other plants until the flower heads and pods have formed. It grows in scattered clumps about 12 inches wide, or in irregular patches which may be from 10 to 20 feet or more across. The flat clumps or bunches of arrow-grass grow from 6 to 12 inches high; and each clump of leaves bears a straight slender flower-stalk, growing to

a height of from 12 to 30 inches. The flowers and seed-pods form a slender cluster from 6 to 12 inches long. The flowers themselves are tiny greenish things, and are soon followed by the oblong three-sided seed-pods.

The leaf of arrow-grass is slender, bright-green, very much like grass or sedge. Still it may readily be told from grass by the fact that it is not flat like a grass-blade, but is thick and spongy, flat on one side and round on the other. The leaf of arrow-grass is soft, not wiry and tough like that of a sedge. The leaves are attached to an underground stem, about as thick as a lead-pencil, which pushes its way along beneath the surface, sending up leaves and sending down numerous fibrous roots. The general appearance of the plant is shown in Figures 1, 2 and 3. A flower cluster and a cluster of seed-pods are shown in Figures 5 and 6.

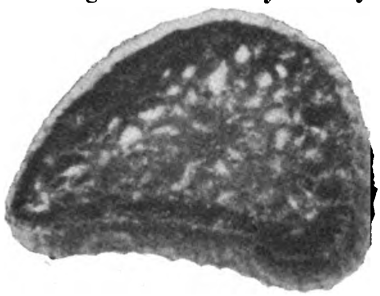


Figure 4. Cross-section of Arrow-Grass leaf, greatly magnified. (X20). The leaf of Arrow-Grass is thick and spongy, not thin and flat like that of ordinary grasses.

Distribution.

Arrow-grass is widely distributed over the northern half of the world. In North America it is found from New Jersey to California and from Labrador to Alaska. On the sea coast it grows in salt marshes; inland it may be found in wet alkaline soils and along the edges of sloughs. associated with grasses and sedges and other plants which require much water.

Three species of arrow-grass occur throughout North America in wet saline or semialkaline soils. At least two of them occur in the pastures and meadows in Nevada, but *Triglochin maritima* being the larger plant and the most common is probably the one responsible for most of the stock losses that occur from eating this plant. It is not definitely known if the other species are sufficiently abundant and poisonous to be dangerous.

Losses Due to Arrow-Grass.

But little is known concerning the extent of animal losses caused by arrow-grass. It has not been generally considered poisonous, and many losses attributed to other causes may have been due to this plant. Dried arrow-grass mixed with hay or fed free from mixture is readily eaten. The green plant does not seem to be distasteful to animals, and it is sometimes eaten greedily, although many other poisonous plants. especially those containing alkaloids, are so bitter that stock will eat them only when forced to do so by extreme hunger.

Because of its rather pleasing and acceptable taste and because of the fact that the plant often grows in almost pure patches from a few feet to rods across and produces a large quantity of forage, it would seem easier for animals either on pasture or on hay to get a fatal dose of arrow-grass than of poisonous plants which grow scattered here and there amid other foliage.

The Poisonous Principle of Arrow-Grass.

An air-dried sample of the plant (*Triglochin maritima*) used in the feeding experiments was examined in the Station Laboratory and was

found to possess cyanogenetic properties, *i. e.*, would yield hydrocyanic acid ("prussic" acid) upon suitable treatment.

That this might be expected was, in a measure, suggested by the symptoms observed in the feeding experiments. In the literature it appears that Greshoff[1] found from 0.02% to 0.6% of hydrocyanic acid

Figure 5. Flowers of Arrow-Grass magnified (X2). Flower is small, greenish, and insignificant.

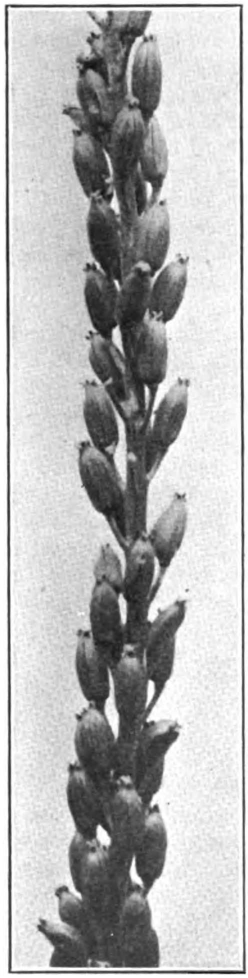


Figure 6. Seed-pods of Arrow-Grass magnified (X2).

n *Triglochin maritima.* Later Blanksma[2] in working with the same plant found hydrocyanic acid in amounts varying from 0.056% to 0.184%.

[1]Greshoff, M.: A New Natural Group of Plants Containing Hydrocyanic Acid. Pharm. Weekblad, 45. 1165–69, 1907.

[2]Blanksma, J. J.: Hydrocyanic Acid in Sour-Grass (Triglochin). Pharm. Weekblad, 50. 295–1302.

In the plants known as cyanogenetic plants, substances have been found in which hydrocyanic acid is in combination with other compounds. As an example of such compounds may be cited amygdalin, a compound, which will yield hydrocyanic acid and benzaldehyde, found in the bitter almond. Compounds of this sort may be made to give up their hydrocyanic acid by the action of suitable reagents, such as by the action of acids upon amygdalin. Another method of breaking off the hydrocyanic acid is by the action of certain ferments. Almost invariably the cyanogenetic substance is found to be accompanied in the plant by a ferment most suitable for that substance. When the cells of the plant are broken the ferment has opportunity to act upon the hydrocyanic acid-holding compound and the acid is liberated.

The poisonous properties of the cyanogenetic plants may be reasonably thought to be due to hydrocyanic acid liberated as described above. That other poisons are present may be possible and has been suggested, but laboratory examination has failed to disclose the presence of notable amounts of other poisonous substances such as alkaloids or saponins.

In the sample submitted, which had lost 79.2% of moisture in drying, there was found 0.264% hydrocyanic acid. Calculated to the original green weight of the plant, this is equivalent to 0.0549% hydrocyanic acid in the original plant. That there is a possibility that a part of the hydrocyanic acid originally present in the green plant was lost in drying, has been shown to be the case in the drying of sorghums. This would make the above figure lower than it should be for the green plant. Dowell[3] showed that in the drying of sorghum approximately three-fourths of the acid is set free.

Laboratory evidence in this case shows that we have been dealing with a cyanogenetic substance, the nature of which will form the subject of a more technical paper from this Station in the future.

Poisonous plants of this type sometimes appear to have an erratic action both in feeding experiments and also when animals are grazing at will. Apparently the grazing of sheep and cattle upon such plants has not been accompanied with fatal results in every case. The areas from which the samples used in these experiments were obtained have been and are used for the grazing of sheep with the only results that at times lambs succumb. Cattle have been fed safely upon sorghums which unquestionably contained hydrocyanic acid and which at other times and under different conditions of feeding caused fatal results. The leaves of the choke-cherry contain hydrocyanic-producing substances, but poisoning does not necessarily accompany natural feeding, although fatal results have been reported. Linseed cake has been the subject of many experiments,[4] and has been found to contain lethal doses of hydrocyanic acid in the amounts fed, but still was successfully used in feeding and fattening.

In explaining such a state of affairs it is necessary to consider all of the possible factors which contribute to the action of these compounds. Auld[4] has pointed out that under digestive conditions cyanogenesis is likely to be inhibited. He shows that the presence of acids, alkalies, salts, cellulose and glucose all tend to prevent the liberation of the

[3]Dowell, C. T.: Cyanogenesis in Andropogon Sorghum. J. Agr. Res. (1919) 16, 17, 175–81.

[4]Auld, S. J. M.: Cyanogenesis under Digestive Conditions. Jour. Agr. Sci. (1913) 5 408–33.

poison, and that in the cases of feeding in which poisoning occurs it is likely that there is some element which interferes with the inhibition which would normally take place. The possibility of the formation of hydrocyanic acid in the food before feeding is very likely in cases in which the feeding stuff is manipulated or prepared before administration. In the case of green food, only the rupturing of the cells is sufficient to produce the free poison, and in the case of the dry material, which is generally more or less broken up, it is only necessary to introduce moisture to produce the free poison. If inhibition can be due to an alkaline medium, the normal conditions in the mouth during eating and in the rumen of the animal would have a protective action and would tend to prevent poisoning. Anything interfering with normal mastication and the attendant mixing of saliva with the food would evidently interfere with the inhibitory process and end with disastrous results. Auld (loc. cit.) points out the protective effect of cellulose and glucose, and that these carbohydrates have an inhibitory action on the evolution of hydrocyanic acid has been observed by other investigators with other plant materials. In fact, it has been recommended[5] that glucose be used as an antidote in cases of poisoning from this source. As a matter of fact, it is probable that the administration of glucose would have but little effect if done after the symptoms of acute poisoning have developed. However, if a suspicious food was to be fed, it might be mixed with a glucose-containing material as a precautionary measure.

Another and equally important factor is that of the physical condition of the animal when fed; the state of its health and whether the food in question is taken upon a partially filled or empty stomach. It would appear in the case of sorghum, for example, that cows turned into sorghum would be fatally poisoned if nothing had been eaten for a short time previously; but if they were first fed and then allowed access to the same plants no poisoning would follow.

The Season of the Year when Arrow-Grass Is Poisonous.

Feedings were made with arrow-grass cut both in early summer and during fall. It appeared equally poisonous at both seasons. There is good reason for believing that the plant is toxic during the entire period of its growth.

The Part of the Plant which Is Poisonous.

The greater part of arrow-grass consists of the leaves, the flower stalk making only a small portion of its total weight. The leaves have been conclusively proven to be poisonous. We have not found out whether the flower stalks are poisonous because they are more or less tough and unpalatable and make up only a minor part of the total weight of the plant. The roots are so firmly held down by their fibrous growth that there is little or no chance of their being eaten.

The following tables give the feeding tests which were made with sheep and cattle in the fall of 1918 and the spring and summer of 1919; all the animals were fed the fresh green leaves except a single sheep weighing seventy pounds which was fed three-fourths of a pound of the green fruits without results:

[5]Peters, A. F., Slade, H. B., and Avery, Samuel: Poisoning of Cattle by Common Sorghum and Kafir Corn. Nebraska Station Bulletin No. 77.

SHEEP-FEEDING TESTS WITH GREEN MATERIAL, 1918–1919

Animal No.	Weight of animal	Date	Time fed	Amount fed	Time symptoms appeared	Time of death or recovery	Final result
42	70 lbs.	10-7-1918	4:40 p. m.	¾ lb.	None		
40	100 lbs.	10-7-1918	4:30 p. m.	1 lb.	None		
39	97 lbs.	10-8-1918	3:10 p. m.	4½ lbs.	3:25 p. m.	4:13 p. m.	Death
42	75 lbs.	10-10-1918	4 p. m.	2 lbs.			Slightly sick
		10-15-1918	11:40 a. m.	2 lbs.	12:05 p. m.	1:40 p. m.	Death
46	72 lbs.	10-29-1918	2:30 p. m.	3 lbs.	None		
	75 lbs.	11-7-1918	9 a. m.	2¾ lbs.	None		
26	75 lbs.	4-12-1919	9 a. m.	1 lb.	None		
29	81 lbs.	4-15-1919	9:30 a. m.	1 lb.	None		
26	75 lbs.	4-15-1919	9:40 a. m.	1½ lbs.	None		
	73 lbs.	6-3-1919	11:40 a. m.	1½ lbs.	12:50 a. m.	1:15 p. m.	Death
46	70 lbs.	6-3-1919	1:15 p. m.	1 lb.	None		
		6-4-1919	10:50 a. m.	1¾ lbs.	None		
		6-5-1919	10 a. m.	1½ lbs.	None		
		6-6-1919	10 a. m.	2 lbs.	None		
		6-7-1919	2 p. m.	2¼ lbs.	None		
		6-11-1919	2 to 4 p. m.	2½ lbs.	4:30 p. m.	7 p. m.	Recovery
		6-12-1919	9:20 a. m.	2½ lbs.	9:30 a. m.	9:55 a. m.	Death
29	80 lbs.	6-11-1919	9 to 10:20 a. m.	1½ lbs.	10:30 a. m.	10:55 a. m.	Death

As a result of the twenty feeding tests, 7 sheep were poisoned, 5 of which died. The weight of green material required to make a sheep sick or to kill it varied from 1½ pounds to 4½ pounds, the average fatal dose being approximately 2.4 pounds. Because of the extremely irregular way in which plants containing hydrocyanic acid act on animals, it would be difficult to state accurately just how much of the plant is required to kill a sheep or to make it sick.

However, the above tests demonstrate conclusively that arrow-grass is a plant containing an active poison, and, although the amounts necessary to produce sickness or death may seem high, in reality they are not; for the plant is made up of a rather open cellular structure containing a high percentage of water. Further, when poisoning does take place death is likely to follow; this is shown by the fact that of 7 animals poisoned 5 died. Four of the deaths were caused by 2½ pounds or less of green material.

A series of feeding tests with cattle made in spring, summer and autumn with green arrow-grass failed to cause poisoning. The tests are summarized in the table at the top of page 13.

Two pounds of green arrow-grass had no effect on Steer No. 735. In October this animal ate an average of 15¾ pounds daily for 7 days or a total quantity of 110¼ pounds, with no bad effects. The material for this test as shown in the table was collected during October. The June feeding tests also resulted negatively.

These results cannot be taken to mean that fresh green arrow-grass is not poisonous to cattle; for we must constantly keep in mind the irregular and apparently inconsistent action of plants containing hydrocyanic acid. There is a possibility that under different conditions of feeding and at another time the feeding of the same quantity or even less would have caused poisoning. Many valuable forage plants in the sorghum group contain hydrocyanic acid; and yet they are ordinarily fed without causing losses. However, on the other hand, rather serious losses in cattle have been caused by the sorghums. With arrow-grass, the same erratic action may be expected. This test would seem to indicate that pastures where arrow-grass grows are ordinarily not dangerous to cattle; still, there is always a possibility that they may eat just the right amount at the right time with deadly results.

Cattle-Feeding Tests with Green Leaves, 1918–1919

Animal No.	Weight of animal	Date fed	Time fed	Amount fed
735	530 lbs. 515 lbs.	10-10-1918 10-10-1918	3 p. m. 4 p. m.	2 lbs. 9¼ lbs.
		10-12-1918	9 a. m.	11 lbs.
		10-15-1918	9 a. m.	19 lbs.
		10-22-1918	12 p. m.	20 lbs.
		10-23-1918	10 a. m. 2 p. m.	14 lbs.
		10-26-1918	2 p. m.	23 lbs.
		10-27-1918	9 a. m.	....
		10-27-1918	12 m.	10 lbs.
		10-27-1918	4 p. m.	4 lbs.
1	137 lbs.	4-15-1919	11:30 a. m.	1¾ lbs.
		6-4-1919	10 a. m. 8:30 p. m.	13¼ lbs.
		6-5-1919	1 p. m. 8 p. m.	8¾ lbs.
		6-6-1919	8 a. m. 1 p. m.	6½ lbs.
		6-7-1919	3 p. m.	2¼ lbs.
		6-8-1919	2 p. m.	4 lbs.
		6-10-1919	1 p. m.	8½ lbs.
7	141 lbs.	6-10-1919	5:30 p. m. 10:30 p. m.	8¼ lbs.
		6-11-1919	8:30 a. m. 5 p. m.	13¼ lbs.

Feeding Arrow-Grass in Hay.

The following feeding tests were made with sheep and cattle to determine the effect of various proportions of dry arrow-grass when put up in hay and fed. The plant material for these feedings was collected in 1919 on a ranch near Reno. One lot of 26½ pounds of fresh arrow-grass was collected June 3, 4 and 5 and air-dried to 5½ pounds. Another lot of 38¾ pounds was collected on August 9 on the same ranch and air-dried to 9 pounds.

Sheep-Feeding Tests with Air-Dried Arrow-Grass

Animal No.	Weight of animal	Date fed	Time fed	Amount fed	Time symptoms appeared	Time of death or recovery	Final result
60	94 lbs.	8-5-1919	4 p. m.	8 ozs.	4:50 p. m.	5:50 p. m.	Death
37	83 lbs.	8-5-1919	4:20 p. m. 4:45 p. m.	12 ozs.	5:30 p. m.	Night	Recovery
58	101 lbs.	8-6-1919	10 a. m. 11:30 a. m.	4 ozs.	5:15 p. m.	9:30 p. m.	Recovery
53	109 lbs.	8-6-1919	10 a. m. 11:30 a. m.	4 ozs.	....	....	Negative
54	115 lbs.	8-6-1919	2:30 p. m. 3:30 p. m.	5¼ ozs.	4 p. m.	4:35 p. m.	Death
58	100 lbs.	8-7-1919	1:30 p. m. 2:30 p. m.	4 ozs.	3:20 p. m.	7 p. m.	Recovery
51	96 lbs.	8-15-1919	3:30 p. m.	1 oz.	....	....	Negative
53	105 lbs.	8-15-1919	3 p. m.	1 oz.	....	....	Negative
58	100 lbs.	8-16-1919	8:50 a. m.	3 ozs.	....	....	Negative
51	96 lbs.	8-20-1919	6:50 a. m.	1 oz.	....	....	Negative
37	87 lbs.	8-20-1919	7 a. m.	2 oz.	....	....	Negative
61	100 lbs.	8-20-1919	7:20 a. m.	3 ozs.	8:30 a. m.	10:15 a. m.	Death
62	82 lbs.	8-20-1919	7:30 a. m.	2¼ ozs.	8:03 a. m.	9 a. m.	Death

Tests with a Yearling Calf

1	133 lbs.	8-8-1919	9:30 a. m.	7 ozs.	9:50 a. m.	10:20 a. m.	Death

Thirteen feeding tests were made with the air-dried material fed to sheep, six of which tests either made the animal very sick or else caused death. These tests prove conclusively that small amounts of the dried plant are highly poisonous to sheep. The smallest amount which was fatal to a sheep was 2¼ ozs., the average fatal dose being approximately

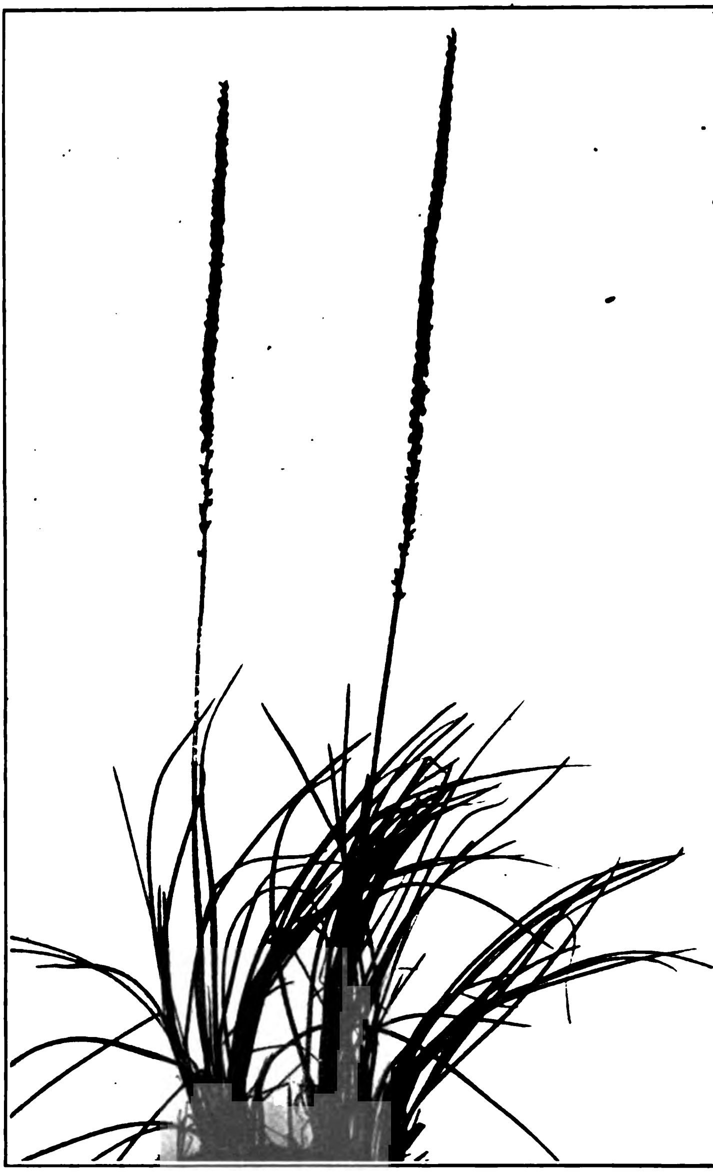


Figure 1. Typical plant of Arrow-Grass, showing cluster of leaves and two flower stalks.

Figure 2. Arrow-Grass, growing among other plants and grasses.

Case No. 2—No. 42.

A ewe weighing 75 pounds was fed 2 pounds of green arrow-grass leaves at 11:40 a. m.; at 12:05 p. m. she was walking with a stiff peculiar gait the hindlegs far apart and held back. Soon muscular twitchings commenced. At 12:25 p. m. the respiration was 25. At 12:30 she fell down, displaying spasms with a peculiarly regular up-and-down movement of the head. Spasms occurred at short intervals until a little before death. At 1:28 p. m. the respiration was 19. At 1:37 p. m. the mouth was held open with the tongue out and breathing had almost ceased. Death occurred at 1:40 p. m.

Autopsy showed moderately congested abomasum, spleen dark and mushy, small intestine congested, lungs slightly congested; all other organs apparently normal.

Case No. 3—No. 26.

A yearling wether weighing 73 pounds was fed 1½ pounds of green arrow-grass leaves at 11:40 a. m. At 12:50 p. m. he was down on his

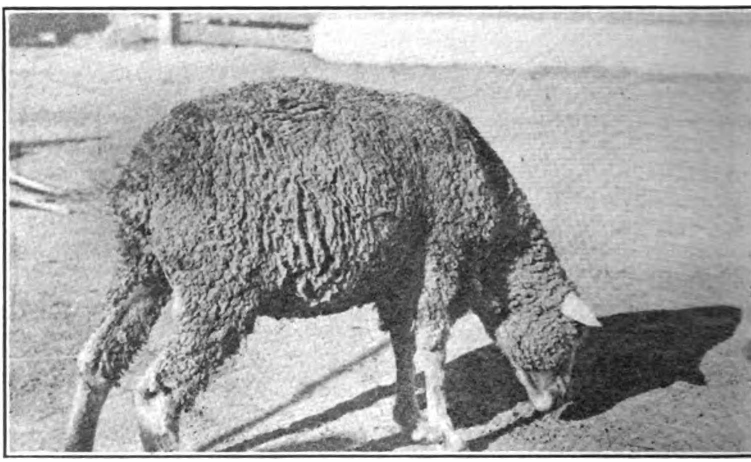


Figure 7. Sheep in early stages of Arrow-Grass poisoning.

belly with legs stretched out, mouth open; very audible breathing through mouth, and distinct twitching movements of head and rolling of eyes. At 1 p. m., respiration 16, temperature 103.2. Had a series of spasms at regular short intervals until death, which occurred at 1:15 p. m.

Autopsy showed fourth stomach slightly reddened, small hemorrhages on heart; spleen darkened; all other organs apparently normal.

Case No. 4—No. 46.

A ewe weighing 70 pounds was fed 2½ pounds of green leaves of arrow-grass between 2 p. m. and 4 p. m. She commenced to feel distressed and acted unnatural almost as soon as the feeding was finished, standing with head down, appearing very dull and caring little to move about. This state of inactivity was maintained until 5:45 p. m. when she commenced to brighten up, and at 7 p. m. appeared quite normal, for she was eating a little hay.

Case No. 5—No. 46.

The same sheep as in Case No. 4 was again fed the next day 2½ pounds at 9:20 a. m. and was very sick by 9:30 a. m. She was breathing through the open mouth, with frequent twitching movements of the muscles of the neck, wrinkling movements of the lips and a chewing movement of the jaws. At 9:45 a. m. she was down on her side with spasms most of the time until 9:50 a. m., when she began to regurgitate

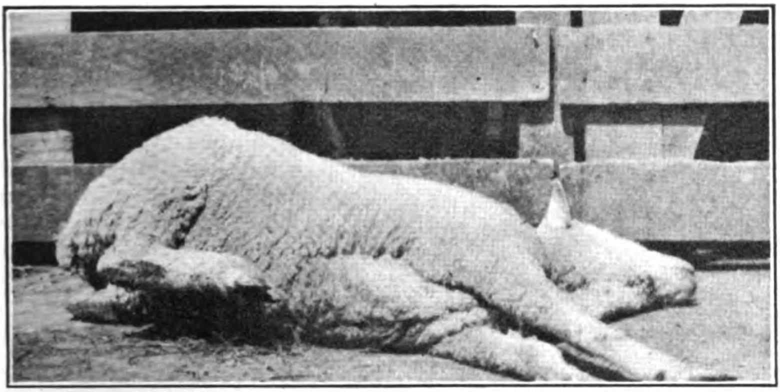


Figure 8. Sheep down in convulsions, Arrow-Grass poisoning.

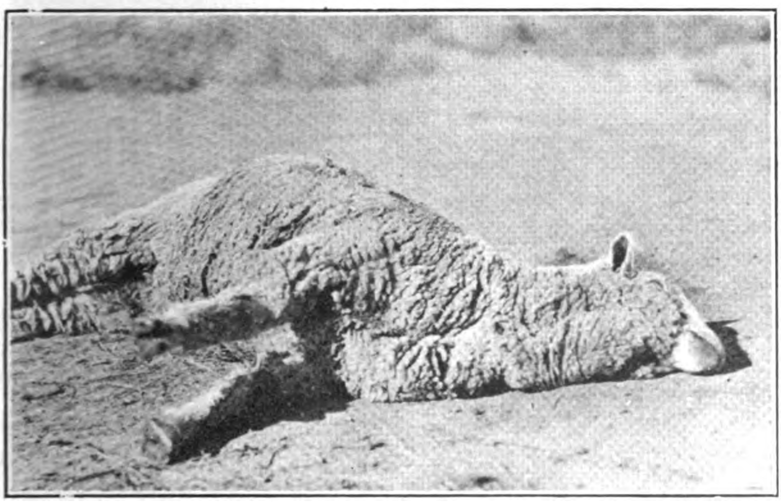


Figure 9. Sheep dying from Arrow-Grass poisoning.

food which passed out both through the mouth and nostrils. Death occurred at 9:55 a. m., thirty-five minutes after she was fed.

Autopsy (by Dr. R. C. Louck): Slight congestion of fourth stomach, large intestine congested; small hemorrhages on ventricles; all other organs apparently normal.

Case No. 6—No. 29.

A yearling lamb weighing 80 pounds was fed three-fourths of a

pound of green material between 9 a. m. and 10: 20 a. m. He was sick at 10: 30 a. m. ten minutes afterwards. Breathing through the mouth was very audible; and the animal was soon down on its side. The respiration was 50, temperature 101.4. He lay on his side with difficult breathing and series of spasms at frequent intervals until shortly before death, which occurred at 10: 55 a. m., thirty-five minutes after feeding.

The autopsy showed small hemorrhages of the heart; all other organs appeared normal. Because of regurgitation shortly before death, the lungs contained food material.

Case No. 7—No. 60.

A ewe weighing 94 pounds was fed 8 oz. of the dry leaves at 4 p. m. At 4: 50 p. m. she was down and unable to rise. Peculiar jerky movements of the head took place. At 5 p. m. she began having a series of convulsive spasms at intervals of four or five minutes until death, which occurred at 5: 50 p. m. Just before death she vomited a little.

Autopsy showed slight inflammation of colon; severe congestion of both lungs; slight hemorrhages in the endocardium of the ventricles.

Case No. 8—No. 37.

A ewe weighing 83 pounds was fed 12 ozs. of the dry leaves between 4: 20 p. m. and 4: 45 p. m. At 5: 30 p. m. she was dull and could hardly be induced to get up. Slight jerky movements of the muscles of the head and neck took place, becoming more pronounced until 7: 20 p. m. When next observed, at 9: 30 p. m., she was much better, being up and walking about, but still very much indisposed. Next morning at 8 a. m. she appeared to have fully recovered.

Case No. 9—No. 58.

A ewe weighing 101 pounds was fed 4 ozs. of the dry leaves between 10 and 11: 30 a. m. At 5: 15 p. m. she was breathing rapidly, the respiration being 150 per minute. This condition lasted until 7 p. m. No other symptoms were observed. Next morning she was eating a little hay; at 9: 30 a. m. the following day she appeared to have fully recovered.

Case No. 10—No. 54.

A ewe weighing 115 pounds was fed 5½ ozs. between 2: 30 p. m. and 3: 30 p. m. At 4 p. m. she was sick, breathing through the mouth; respiration, 104; temperature, 103.6. While standing, frequent jerky muscular movements of the whole body took place. At 4: 12 p. m. she was down with head and legs moving almost constantly, except during spasms when the legs were stretched out and the head and neck drawn back. The animal died at 4: 35 p. m.

Autopsy showed considerable congestion in rumen and fourth stomach; spleen darkened and mushy; kidneys congested; abdominal lymph glands congested; lungs moderately congested.

Case No. 11—No. 58.

A ewe weighing 100 pounds was fed 2 ozs. of the dry leaves at 1: 30 p. m. and 2 ozs. more at 2: 30 p. m. At 3: 20 she was sick; respiration, 70; breathing deep and audible; trembling of the muscles, especially those of the legs. At 3: 40 she was down; respiration 30; breathing hard and very audibly through the mouth. She remained down with

head flat on the ground until after 5:10 p. m. At 5:50 p. m. she was up and able to walk, but still quite weak. At 7 p. m. she appeared to have fully recovered.

Case No. 12—No. 61.

A ewe weighing 100 pounds was fed 3 ozs. of air-dried leaves at 7:20 a. m. At 8:30 a. m. she was sick. Down on side with spasms at 9:30 a. m.; respiration, 44; temperature, 103.6. Breathing was mainly through the mouth. At 10 a. m. she was lying quietly on her side, breathing hard and audibly. Died at 10:15 a. m.

Autopsy showed considerable congestion of lungs and a few small hemorrhages of the heart. Other organs presented no gross lesions.

Case No. 13—No. 62.

A ewe weighing 82 pounds was fed 2¼ ozs. of dry arrow-grass leaves at 7:30 a. m. Sick at 8:03 a. m., having a peculiar twitching of the muscles. Down on one side at 8:30 a. m. Frequent spasms occurred.

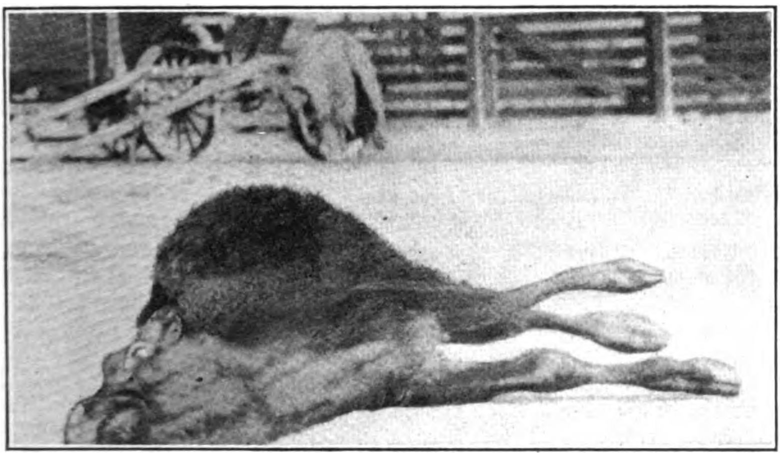


Figure. 10. Calf dying in convulsions from Arrow-Grass poisoning.

Respiration, 65; temperature, 104.2. At 8:45 a. m. respiration had fallen to 28. Death took place at 9 a. m.

Autopsy showed congestion of lungs and of the fourth stomach. Other organs appeared normal.

Case No. 14—No. 62.

A ewe weighing 82 pounds was fed 4 ozs. of dry leaves, an ounce at a time hourly in order to find out if the poison would be eliminated fast enough so that poisoning symptoms would not develop. The last feeding was at 4:20 p. m. and at 5 p. m. she was sick. The first noticeable symptom was a trembling of the muscles of the legs; respiration, 70. At 5:02 p. m. she was down, breathing through the mouth. She remained in this condition until after 6:30 p. m. At 7:30 p. m. she was up, walking around, but soon fell down again. She was soon on her feet again, but at 7:40 she had another spasm and fell down. At 10:30 p. m. she was up and able to walk around, her gait was very unsteady; the next morning at 7:30 a. m. she appeared to have fully recovered.

Case No. 15—No. 1.

A small yearling calf was fed 8 ozs., of which almost 1 oz. was left uneaten at 9:30 a. m. At 9:50 a. m. he was sick. Most of the time he lay on his side and at frequent intervals he had spasms when his head would be pulled back and legs stretched out. At 10:15 the respiration was 10; and he appeared to be dying. He died at 10:20 a. m.

The autopsy revealed no lesions.

Symptoms of Poisoning.

The first symptom noted was abnormal breathing, usually very rapid, often as high as 150 per minute, in sheep. In other cases it was slow and deep. As symptoms of poisoning developed, the animal breathed quite freely through the mouth, often with the tongue hanging out. This abnormal breathing was often accompanied by trembling or jerking movements of the muscles. In severe cases these jerking movements would develop into spasms or convulsions. After these started the animal would lie on its side panting through the wide-open mouth. From the time the animal went down until partial recovery or death there would be a series of convulsions at short intervals. Several of the animals vomited just before death, drawing part of the regurgitated material into the lungs, which may have hastened death.

Autopsy Findings.

The autopsy findings are few and not characteristic in any way, with the possible exception of congestion of the lungs. Fifty per cent of the cases showed endocardial or epicardial hemorrhages and forty per cent a spleen that was dark and mushy. In general, the blood was darker than normal and formed a clot that was rather soft. The moderate congestion observed in the intestinal tract is of little significance, and, because of the lack of uniformity of the location of the lesion, might be due to other causes. No odor of cyanide was noted in any of the cases; but all the autopsies were made in the open.

If these deaths were due to cyanide poisoning as indicated by the symptoms and chemical findings, the autopsy findings would probably be negligible. Various writers on toxicology consider the post-mortem changes in cyanide poisoning as of little aid in diagnosis. Nunn (Veterinary Toxicology, 1907, p. 130) states: "The post-mortem appearances are nothing characteristic, excepting the pervading smell of almonds from the intestines and in a lesser degree from the whole body." Friedberger and Frohner (Veterinary Pathology, Vol. I, Translation by Hayes, Sixth Edition 1908, p. 236) say: "Autopsy shows bright-red blood in acute cases, brown when chronic; smell of bitter almonds; signs of asphyxia."

Feeding Conditions under which Poisoning by Arrow-Grass Is Likely to Occur.

Few cases of natural poisoning have been observed. In one instance an owner of live stock stated that he had had a number of cows in corral on dry feed for some time. On releasing them they went directly to a patch of arrow-grass which they ate greedily. There was very little grass or sedge in the patch. The poisonous material was therefore but little diluted, and the death of several animals soon followed. The same stockman reported that he was very likely to lose animals when they were fed from a stack of wild-grass hay cut on

meadows containing large quantities of arrow-grass. A sheep owner reported the death of lambs when they fed late in the spring on meadows where arrow-grass was abundant. From the statement it appeared probable that death was due to this plant.

There seems some reason to believe that the plant might cause death in animals which had been on dry feed so long that they would fill up on almost anything green. There appears to be greater danger when the plant is fed dry in hay; the dose required to kill is then far smaller, and there is greater probability that a fatal quantity will be eaten.

Cure of Animals Poisoned with Arrow-Grass.

No experiments were made to determine whether it would be possible to cure a poisoned animal. Apparently there is little hope or prospect of success, because a dose large enough to cause illness is likely to cause death, and because the interval between the time when the first symptoms appear and the fatal result is too short to permit of treatment.

Prevention of Poisoning.

With arrow-grass as with other poisonous plants it appears that not much can be hoped for in the cure of animals already poisoned, but that a good deal can be done to prevent poisoning. Wet meadows, where arrow-grass is very common, should not be cut for hay. However, where the plant is distributed in small clumps rather uniformly and is not very abundant there is little danger. The largest clumps should not be cut, or, if cut, should not be loaded on the wagons and should be burned when dry. Animals should not be put on pastures containing an abundance of arrow-grass when they are very hungry. In some cases, moreover, portions of pastures and meadows where arrow-grass grows in great abundance should be fenced and left unused. By these methods it should be easy to prevent losses due to this poisonous plant.

PUBLICATIONS

The following bulletins are available for distribution and may be had free by applying to the Director of the Agricultural Experiment Station, Reno, Nevada:

No. *Title*

31........Texas Cattle Fever.
32........Sugar-Beets.
52........Water Supply and Irrigation in Nevada.
70........Food and Drug Inspection.
71........Digestion Experiments on the Range.
73........A Neglected Field in Photomicrography.
74........Report of Department of Food and Drug Inspection, 1910.
76........The Potato Eelworm.
77........Fixing Standard Weights and Measures.
78........Hymenopterous Parasites (Technical) Entomology.
79........Avoidance and Prevention of Frosts in Fruit Belts of Nevada.
80........Food and Drugs and Weights and Measures Laws in Nevada.
81........Water Hemlock (Technical).
83........Value of High-Level Meteorological Data in Forecasting Changes in Temperature.
84........The Control of Contagious Epithelioma in Chickens by Vaccination. (Popular Abstract of Bul. 82, amplified and illustrated.)
85........The Use of Bacterins in the Control of Fowl Cholera.
86........Forage and Root Crops.
89........Grain Production in Nevada.
90........Potato Culture in Nevada.
92........Irrigation of Wheat in Nevada.
93........Irrigation of Alfalfa in Nevada.
94........One-Night Camps vs. Established Bed-Grounds on Nevada Sheep Ranges.
96........Irrigation of Field Crops in Nevada.
97........Don't Feed Fox-Tail Hay to Lambing Ewes.
98........Arrow-Grass, a New Stock-Poisoning Plant.
Annual Reports for 1910, 1911, 1913, 1914, 1915, 1916, 1917, 1918.

Circulars:

1........Glanders.
5........Inspection of Nursery Stock.
13........Anthrax.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION
S. B. DOTEN, Director

Bulletin No. 99 | RENO, NEVADA | December, 1920

To diminish suffering and loss among domestic animals

THE NARROW-LEAVED MILKWEED
(*Asclepias Mexicana*)

and

THE BROAD-LEAVED OR SHOWY MILKWEED
(*Asclepias speciosa*)

PLANTS POISONOUS TO LIVE STOCK IN NEVADA

By

C. E. FLEMING and N. F. PETERSON
Of the Department of Range Management

Assisted by

M. R. MILLER
Of the Department of Chemistry

and

Dr. L. R. VAWTER and Dr. L. H. WRIGHT
Of the Department of Veterinary Science

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
State Printing Office—Joe Farnsworth, Superintendent
CARSON CITY, NEVADA

182

NEVADA AGRICULTURAL EXPERIMENT STATION

STUDIES OF POISONOUS PLANTS IN THE UNIVERSITY OF NEVADA

In recent years, as the forage on the open public range in Nevada has become more and more depleted, losses of sheep and cattle from poisonous plants have steadily increased. However, even the stockmen and herders themselves do not know fully just which plants are poisonous nor how to avoid them.

The Nevada Agricultural Experiment Station has therefore undertaken a study of the poisonous plants of the sheep and cattle ranges. The experimental work is of a simple character, consisting largely of practical feeding tests. The plants are brought to the University fresh from the ranges and are fed to common range live stock in small corrals. The symptoms of poisoning are recorded; and after the death of the animal the carcass is cut up and the organs are removed and studied.

An attempt is also made to isolate the active poisonous principle of the plant by suitable chemical methods and to determine its chemical nature.

These experiments are showing clearly which range plants are dangerous, what part of the plant is poisonous, and at what season of the year it must be avoided. They are also showing us that many suspected plants are harmless, while others which are considered harmless are in reality deadly.

In all these experiments it is our purpose first to obtain exact information concerning the poisonous range plants and then to spread it far and wide among the stockmen of the West in the hope of diminishing suffering and loss among western sheep and cattle.

S. B. DOTEN,

Director, Nevada Agricultural Experiment Station.

November 1, 1920.

SECTION I

The Milkweeds as Plants Poisonous to Live Stock in Nevada

SUMMARY

(1) There are two common milkweeds in Nevada, both of which are poisonous to sheep and cattle.

(2) One is a slender, erect, branching weed with long, narrow, dark-green leaves, small flowers, and slender pods. The other is a tall and fleshy weed with large, broad, light-green leaves, coarse flowers, and thick rough pods.

(3) Both kinds grow in fairly moist places, along irrigation ditches, by fences and on stream banks, on roadsides, and in patches in damp pastures.

(4) In the autumn the pods break open and release quantities of flat brown seeds, each of which bears a tuft of shining silky hairs, lighter than thistledown. The seeds are carried far by wind and water. Once established, the plant spreads locally by means of its underground stems.

(5) Animals poisoned by the narrow-leaved milkweed become dull and stupid within a few hours. They walk about with a wobbling, unsteady gait, finally losing all control over the muscles of the legs, and falling or lying down. After the animal is down, it has spasms at short intervals in which the legs are extended rigidly. The heart beats at an increasingly rapid rate; the animal pants and grunts. The head is drawn sharply back. The attack may last for twenty-four hours and end with either the death or the recovery of the animal. If it recovers, it will be in a weak and unsteady condition for several days.

(6) Animals poisoned by the broad-leaved or showy milkweed stop eating, grow dull, and lie down; the breathing is irregular, difficult, and grunting. There are no spasms. The breathing becomes more difficult, and the animals dies quietly.

(7) The narrow-leaved milkweed is far more deadly than the broad-leaved or showy species.

(8) Two or three other milkweeds grow in Nevada; but they are neither common enough nor poisonous enough to be of any importance.

(9) When the narrow-leaved milkweed is accidentally cut and cured in hay, it loses its bad flavor, but keeps its deadly character, thus becoming far more dangerous than when fresh and green. Even the dead and dried leaves, left standing in a field from the summer before, are poisonous in midwinter.

(10) It is a costly and difficult matter to get rid of the narrow-leaved milkweed on even a small piece of ground. If a bit of the underground stem is left in the soil, it will soon produce a new plant.

(11) Both of our poisonous milkweeds have so unpleasant a flavor that neither sheep nor cattle will eat them except when they are very hungry and there is practically nothing else in the field for them to eat.

(12) Poisoning may be prevented by keeping hungry animals and animals in poor condition away from milkweed patches, and by stocking pastures lightly enough to keep the animals constantly provided with other food.

Figure 1—Flowers and Pods of the Narrow-Leaved Milkweed.

OUR WESTERN MILKWEEDS

For many years several kinds of milkweed have been looked upon with suspicion or considered poisonous by western stockmen. This opinion was based largely on their own field observations; and little or no experimental work has been done with any of the species except the whorled-leaved milkweed (*Asclepias galioides*). The latter plant has been carefully studied by the Colorado Experiment Station, which was the first of the western stations to show that sheep may be poisoned by this plant when it is eaten either green or dry. (See Bulletins 246 and 255, Colorado Agricultural Experiment Station.) Later, C. D. Marsh and his associates of the Federal Bureau of Plant Industry published the results of their study of the same species. (See Bulletin No. 800, U. S. Department of Agriculture.)

In the spring of 1918 the attention of the Nevada Experiment Station was first called to our local milkweeds as plants dangerous to live stock when several lambs died after eating the tender, juicy young growth of the showy milkweed (Fig. 4). Since that time the Nevada Station has tested the milkweeds by conducting a long series of experiments in which the plants were fed to both sheep and cattle. More work was done with the narrow-leaved milkweed than with any of the others because it seemed to be our most dangerous species. The result of these feeding tests, together with field observations, are presented in this bulletin.

Classes of Live Stock Poisoned and the Extent of Losses in this State and Elsewhere.

Both feeding tests and field observations have shown that the narrow-leaved milkweed (*Asclepias Mexicana*) is poisonous to sheep and cattle. No feedings of any species of milkweed have been made to horses because there seems to be nothing to show that horses have been poisoned by these plants.

Because of the limited time since the milkweeds were recognized as poisonous to live stock in Nevada, the extent of losses cannot be accurately estimated. Further, unless especially large losses take place, they are usually not reported to the Experiment Station. However, because of the widespread distribution of the narrow-leaved milkweed and the ease with which it kills, it is reasonable to assume that losses of live stock, at least in small numbers, are constantly caused by this common poisonous plant.

In other States, notably Colorado, Utah, and New Mexico, it has been proven that the whorled-leaved milkweed has caused the death of many sheep.

Kinds of Milkweed Dangerous to Live Stock in Nevada.

Several kinds of milkweed grow in Nevada but, from the stockman's point of view, the narrow-leaved species is by far the most important. The other kinds will be discussed briefly toward the end of this bulletin. They are: the Showy Leaved Milkweed (*Asclepias speciosa*); the Heart-Leaved Milkweed (*Asclepias cordifolia*); and the Prostrate Milkweed (*Asclepias cryptoceras*). Our experiments seem to show that the heart-leaved and prostrate milkweeds are not poisonous enough or common enough to be dangerous on the range or in pastures in Nevada.

General Description of the Milkweeds.

The milkweeds are usually erect plants, little if at all branched, varying in height from one to several feet. The roots live over from year to year, sending up new stems each season. The flowers are light-colored, white tinged with green or pink; they grow in rounded clusters, each flower stalk arising from the end of the stalk of the cluster.

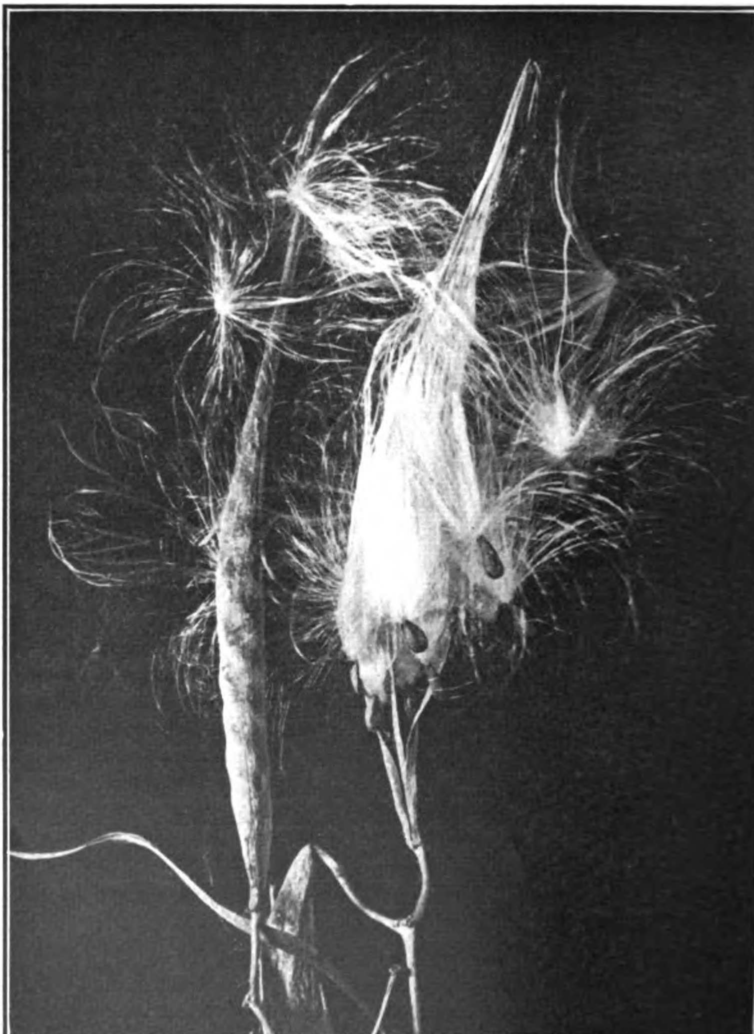


Figure 2—Pods and Seeds of the Narrow-Leaved Milkweed.

Each flower has five cup-like structures (hoods), inside of which there is a horn.

The flowers fall and are followed by seed pods from one to three inches long which open along one side when dry to allow the seeds to escape. The seeds are reddish-brown and flat; on one end there is

a tuft of long, white, silky hairs by which they are blown about. The roots of the milkweeds are somewhat brittle, whitish and thickened; this is especially true of the showy milkweed (Fig. 4). The growth of the root is mainly horizontal, as is shown in Fig. 5—The Root of the Narrow-Leaved Milkweed. Sometimes, however, the roots penetrate the soil like the roots of alfalfa.

The milkweeds have a milky sap or juice which gives to them their common name and distinguishes them from most other plants. However, a milky sap is found in many other plants, such as the Mexican poppy, the dandelion and its close relatives, the wild lettuce, spurges, and dog-banes. From all these plants having a milky juice, the milkweeds may be distinguished by the following differences: (1) the Mexican poppy is spiny, while the milkweeds are not; (2) the dandelion and its near relatives have no erect stem, while the milkweeds have; (3) the general appearance of the wild lettuce is quite different from the milkweeds and its flower and flower clusters (heads) are like tiny dandelions and not at all like the flower or flower clusters of the milkweed; (4) the spurges (*Euphorbia*) are mostly low, branching plants with small leaves, the two halves of which are different in shape and size; (5) some of the dog-banes might easily be mistaken for the narrow-leaved milkweed, but they branch more freely and tend to be bushy, at least toward the top. Their flowers are not scattered in dense clusters and do not have hoods as in the milkweed. The pods are similar to those of the milkweed but more slender; the seeds are also similar but smaller and not so flattened.

How to Distinguish the Narrow-Leaved Milkweed from the Showy Milkweed.

The showy-leaved milkweed is quite abundant in Nevada, but it is not nearly so poisonous as the milkweed with the long narrow leaves. The two are easily distinguished by the following differences: (1) the narrow-leaved milkweed has several leaves at each joint of the stem, while the shown species has but two; (2) the leaves of the showy milkweed are much broader, from one-third to one-half as broad as they are long; (3) the narrow-leaved milkweed has smooth pods, while the showy species has pods roughened by projections. Figures 3 and 4 show the general appearance and characteristics of these two plants.

Where the Milkweeds Grow.

The milkweeds are widely distributed in Nevada. They require fairly wet soil, and do not grow on the drier parts of the range. They are common along irrigation ditches and streams, along roadsides, and in pastures and washes and idle lands which have not been cultivated for a number of years. In such locations the narrow-leaved kind is more abundant. It has a wider distribution than the showy milkweed or any of the other species found in this State.

The milkweeds usually grow in full sunlight, although they may be found in partly shaded places as in orchards and among willows and cottonwoods along streams.

In several places in Nevada the narrow-leaved milkweed has been reported to be getting more abundant. Especially is this true along the banks of irrigation ditches. Wherever irrigation systems have been extended to new ground, this poisonous weed soon grows abundantly along the ditch banks.

Figure 3—The Narrow-Leaved Milkweed.

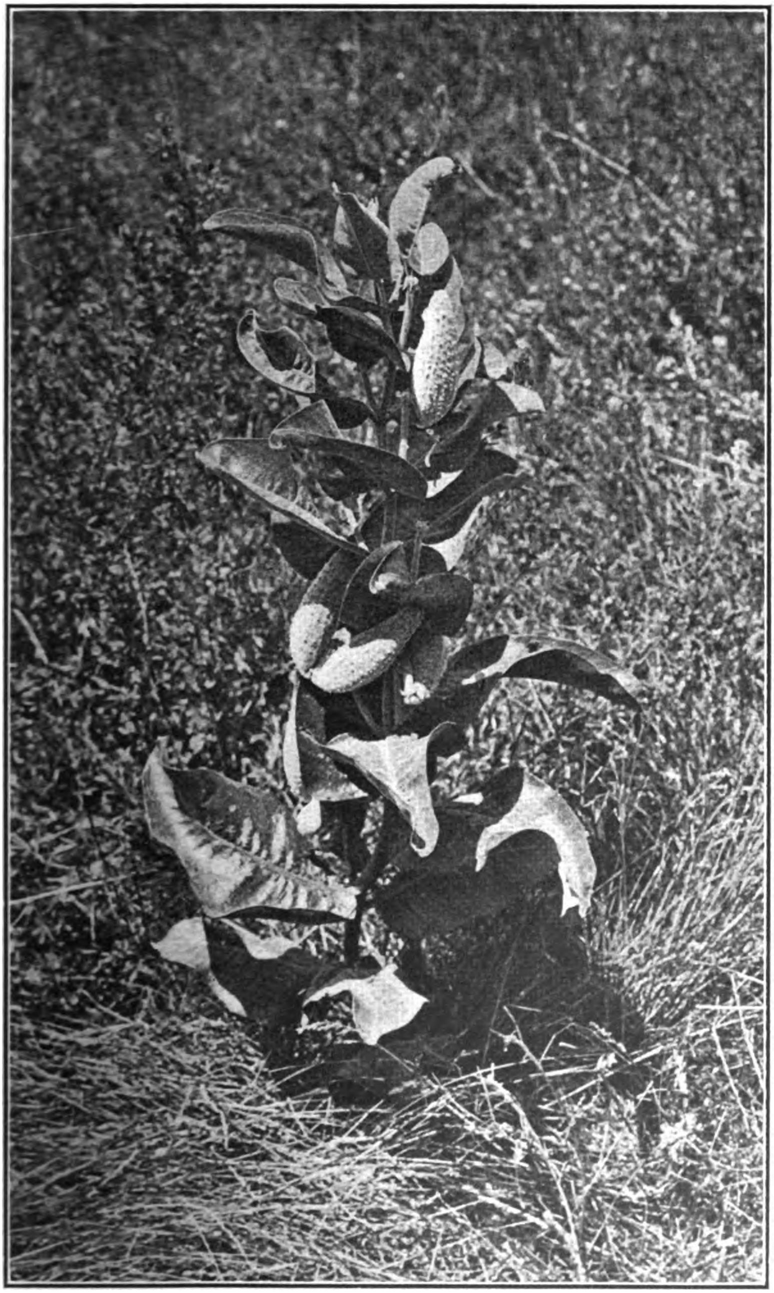


Figure 4—The Broad-Leaved or Showy Milkweed.

All our observations indicate that after it is once established the narrow-leaved milkweed tends to remain confined to the ditch banks and adjoining moist areas. There seems to be little danger of its establishing itself throughout the alfalfa fields and meadow hay lands to such an extent that it would cause the hay to be discriminated against for feeding purposes.

How the Milkweeds Spread.

The milkweeds produce quantities of flat brown seeds, each of which bears a tuft of shining silky hair by means of which it floats on the wind and is carried to considerable distances. Often they are blown into irrigation ditches and carried to distant fields by the water.

New patches may start from seeds, or from pieces of roots carried by plows and other farm implements or picked up by the water and transported to new areas.

Where the plant has become established, the size of the patch is usually increased by the shallow horizontal underground stems which give rise to new plants.

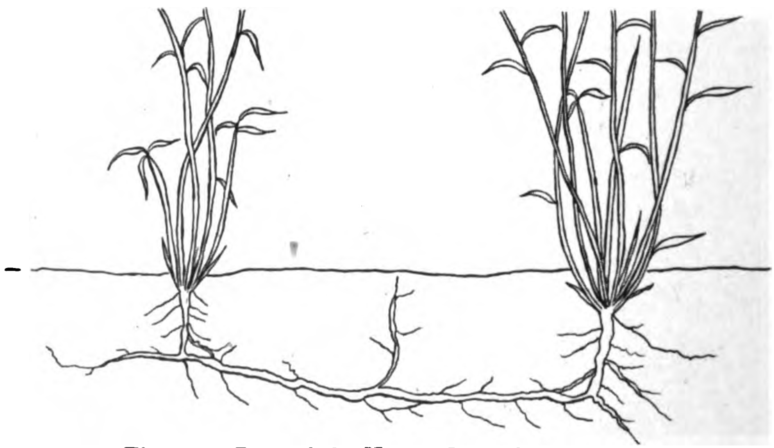


Figure 5—Root of the Narrow-Leaved Milkweed.

It is not uncommon for the same root system to connect up a large number of plants, all of which were produced by the spreading horizontal roots of a mother plant. Thus when it once becomes established it is indeed hard to get rid of this poisonous weed because of the budding of the roots. In some of the milkweeds such buds are known to form as much as two feet below the surface of the ground; and a two-inch piece of the root of the common milkweed was found by A. S. Hitchcock in Kansas to be able to form a new plant. On small areas in Nevada the narrow-leaved milkweed has been dug and pulled two or three times during the season without completely eradicating the plant, because of its ability to produce new plants from small pieces of root left in the soil. Thus any means by which the root is broken up into small pieces and left in the ground will enable the plant to maintain itself and in some instances actually to increase.

THE NARROW-LEAVED MILKWEED (Asclepias Mexicana)

The Part of the Plant Which Is Poisonous.

In our experiments we have fed the whole top of the plant, stems, leaves, and sometimes flowers and seed pods. A few feedings were made of leaves only, and these few tests seem to indicate that the leaves are the most poisonous part of the plant. The pods appear to be less poisonous than either the leaves or the stem. Feeding of seeds alone produced no symptoms. This indicates that the plant is not more dangerous, but perhaps less so, when it is full of seed pods than at other times. For all practical purposes the entire plant may be considered poisonous.

The Time of the Year When It Is Poisonous.

So far as known the narrow-leaved milkweed is poisonous at all stages of growth. Our tests showed it to be poisonous when fed (1) in a green condition, (2) after being cut and dried as hay, and (3) as it dries naturally in the field in the fall. Thus in all stages it is poisonous; and hay containing any large amount of this plant may be regarded as extremely dangerous.

Amount Necessary to Make Sick or to Kill.

We fed the narrow-leaved milkweed to cattle and sheep, (1) in a fresh green state, (2) after being cut and dried, and (3) as it cured naturally on the stems in the fall, (4) the pods alone, and (5) the seeds alone.

TABLE I

The Narrow-Leaved Milkweed—The Fresh Green Plant Fed to Sheep

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result
2	120	5-31-18	2:25 p. m.	½	----------	----------	Negative
28	63	5-31-18	2:30 p. m.	½	----------	----------	Negative
18	95	6- 8-18	4:00 p. m.	½	----------	----------	Negative
25	93	6- 8-18	4:05 p. m.	½	6- 9—7:15 a. m.	6- 9—6:00 p. m.	Recovery
74	98	8-12-20	4:05 p. m.	½	----------	----------	Negative
75	90	8-12-20	4:10 p. m.	½	----------	----------	Negative
78	87	8-12-20	4:15 p. m.	¾	8-13—7:00 a. m.	8-15—8:00 a. m.	Recovery
72	93	8-12-20	4:40 p. m.	¾	8-13—8:00 a. m.	8-14—8:00 a. m.	Recovery
19	68	5-29-18	4:10 p. m.	1	5-30—9:00 a. m.	5-31—8:30 a. m.	Recovery
8	72	5-31-18	2:40 p. m.	1	6- 1—9:00 a. m.	6- 2—9:00 a. m.	Recovery
79	95	8-11-20	4:10 p. m.	1	8-12—8:00 a. m.	8-13—7:00 a. m.	Recovery
8	100	8-12-20	4:20 p. m.	1	8-13—5:00 p. m.	8-14—8:00 a. m.	Recovery
6	65	5-31-18	2:45 p. m.	1½	6- 1—8:00 a. m.	6- 1—4:45 p. m.	Death
77	88	8-12-20	4:30 p. m.	1½	8-13—7:00 a. m.	8-15—8:00 p. m.	Recovery
17	61	5-29-18	4:10 p. m.	2	6:00 p. m.	Before 9:00 p. m	Death

The animals were not watched during the night, usually the first observation being made at 8 o'clock in the morning. This is the reason why, in this and the following tables, under the caption Time of Death or Recovery, "8 : 00 a. m." appears so often. It records the condition of the animal at the first observation made in the morning.

The tests summarized in this table indicate that (1) if common range ewes eat one-half pound or less no serious trouble will follow; (2) amounts in excess of one-half pound and up to 1½ pounds will usually make the animal sick, but it will recover; (3) amounts of 1½ pounds or more are quite likely to cause death.

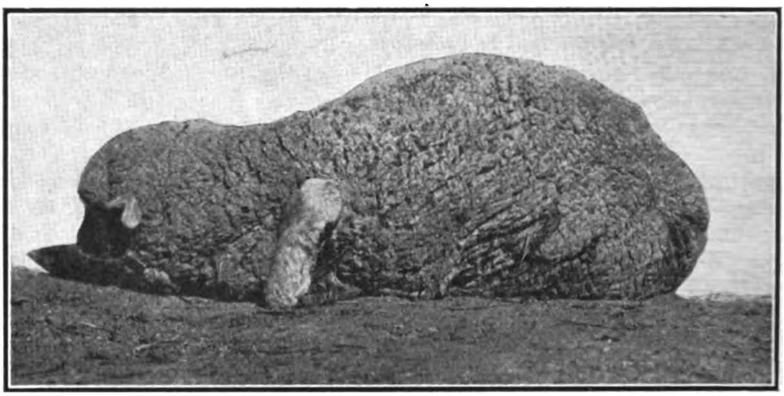


Figure 6—Sheep Poisoned by Narrow-Leaved Milkweed.

Figure 7—Sheep Poisoned by Narrow-Leaved Milkweed.

TABLE II

The Narrow-Leaved Milkweed—The Air-Dried Plant Fed to Sheep

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, ozs.	Time symptoms observed	Time of death or recovery	Final result
56	111	10-17-19	8:20 a. m.	3			Negative
37	90	10-17-19	10:30 a. m.	3			Negative
59	100	10-17-19	8:40 a. m.	4	10-18—8:00 a. m.	10-23—8:00 a. m.	Recovery
56	111	10-21-19	11:30 a. m.	4			Negative
55	112	10-17-19	11:45 a. m.	5	10-18—8:00 a. m.	10-19—8:00 a. m.	Recovery
57	112	10-21-19	11:00 a. m.	5	10-22—8:00 a. m.	10-24—8:00 a. m.	Recovery
46	80	10-20-18	9:30 a. m.	5	10-20—2:00 p. m.	10-23—8:00 a. m.	Recovery
8	100	8-24-20	2:50 a. m.	6	8-25—8:00 a. m.	8-26—8:00 a. m.	Recovery
72	85	8-25-20	2:20 a. m.	7	Not observed	8-26—8:00 a. m.	Death
45	85	11-20-18	10:00 a. m.	8	11-20—2:00 p. m.	11-21—2:45 p. m.	Death

After the green plant has been thoroughly dried in the sun it loses approximately 65% (two-thirds) of its original weight. Its condition is then much the same as it would be if cut and cured in hay. In the feeding tests the air-dried material was in most instances mixed with alfalfa hay and fed.

The feedings of hay and milkweed may be briefly summed up for range ewes as follows: (1) 3 ounces may or may not make the animal sick, (2) 4 to 6 ounces will usually produce poisoning, (3) amounts in excess of 6 ounces will probably cause death.

The dried milkweed is evidently very poisonous. While the plant is green sheep are very likely to avoid it because the taste is repellent; but after it is dry it loses much of its bad flavor and is then more dangerous because more readily eaten.

It takes about three parts of fresh milkweed to make one part of air-dried; and it is an interesting fact that if the above amounts of air-dried material are multiplied by 3 to give the original green weight they agree very closely in most cases with the results of Table I.

The feeding tests given in Table II therefore indicate that drying causes little if any loss of the poisonous principle. Consequently when this milkweed is cut and fed in hay, it becomes a serious source of danger.

TABLE III

The Narrow-Leaved Milkweed—The Plant Which Had Dried Naturally in the Field Fed to Sheep

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result
48	85	11-12-19	2:30 p. m.	3/16	----------	----------	Negative
58	115	11-29-19	1:50 p. m.	5/16	11-30—8:00 a. m.	12- 2—8:00 a. m.	Recovery
43	80	12- 9-19	9:00 a. m.	7/16	12- 9—2:45 p. m.	12-10—8:00 a. m.	Recovery
45	84	12-16-18	10:45 a. m.	3/4	12-17—8:00 a. m.	12-18—8:00 a. m.	Recovery
43	80	12-26-18	11:30 a. m.	1	12-27—8:00 a. m.	12-30—8:00 a. m.	Recovery
43	80	1- 2-19	2:00 p. m.	1¼	1- 2—9:00 p. m.	1- 3—3:00 p. m.	Death

The plants which were used in the above feeding tests were collected in late autumn after they had fully matured and become dry. The feedings were made in the months of November, December, and January. The results may be summed up briefly as follows: (1) small amounts up to 3 ounces are not dangerous, (2) amounts from 5 to 16 ounces will usually produce poisoning, (3) amounts in excess of 16 ounces are extremely dangerous, and are likely to cause death.

Comparing the results given in Table I with those of Table III, it is found that it takes about as much of the naturally cured material, dry weight, to cause death as of the fresh green plant. From this it appears that some of the poison is destroyed or lost when the dried plant stands exposed to snow and rain after the leaves are dead.

During the fall and winter months the dried plants may be found still standing. Other feed is usually very short and scarce at that time of the year; and the narrow-leaved milkweed, still retaining a considerable part of its original poison, is then a source of danger to grazing animals.

TABLE IV

The Narrow-Leaved Milkweed—Seeds Fed to Sheep

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, ozs.	Time symptoms observed	Time of death or recovery	Final result
56	98	9-7-19	3:30 p. m.	2	----------	----------	Negative
59	101	9-7-19	3:40 p. m.	5	----------	----------	Negative

Figure 8 — The First Symptoms of Poisoning by Narrow-Leaved Milkweed.

In late summer and early fall the narrow-leaved milkweed has a large number of seeds and pods. In previous feeding tests the pods and seeds of the showy milkweed were found to be the most poisonous part of the plant; so it was thought that this might also be true of the narrow-leaved milkweed. Two feedings of seeds were made, one of 2 ounces and the other of 5 ounces. Neither animal was poisoned. The quantity of seed which we fed in either test represents the seed production from a large number of plants, a number in excess of what it is believed any animal would be able to get within a reasonable length of time. Consequently it seems that the danger of poisoning from these seeds is very slight and that such poisoning is highly improbable.

TABLE V

The Narrow-Leaved Milkweed—Green Pods Fed to Sheep

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result
73	77	8-17-20	4:20 p. m.	½			Negative
74	98	8-17-20	4:35 p. m.	1			Negative
8	100	8-17-20	4:50 p. m.	2			Negative
69	80	8-19-20	7:40 a. m.	2½	8-20—7:00 a. m.	8-22—8:00 a. m.	Recovery
8	100	8-19-20	7:30 a. m.	3½			Negative

Five feedings of green pods were made, using amounts of from one-half to 3½ pounds. None of these feedings caused poisoning with the exception of one 2½-pound feeding. These tests indicate that the pods are less poisonous than the leaves and stems, and that the danger of loss is smaller when the plant is full of pods.

TABLE VI

The Narrow-Leaved Milkweed—The Dried Plant Fed on Successive Days to Sheep

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, ozs.	Time symptoms observed	Time of death or recovery	Final result
37	85	10-21-19	11:45 a. m.	2			Negative
		10-22-19	11:15 a. m.	2			Negative
		10-23-19	10:30 a. m.	2			Negative
		10-24-19	10:00 a. m.	2			Negative
		10-25-19	7:30 a. m.	2			Negative
		10-26-19	11:00 a. m.	2			Negative
		10-27-19	8:30 a. m.	3			Negative
		10-28-19	10:00 a. m.	3			Negative
		10-29-19	10:00 a. m.	4			Negative
		10-31-19	11:30 a. m.	5	11- 2—7:00 a. m.	11- 3—8:00 a. m.	Recovery

Dry material collected September 6. Sheep never very sick.

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, ozs.	Time symptoms observed	Time of death or recovery	Final result
59	93	10-27-19	11:10 a. m.	2			Negative
		10-28-19	8:30 a. m.	2			Negative
		10-29-19	11:00 a. m.	4			Negative
		10-31-19	10:30 a. m.	4	10-31—2:00 p. m.	11- 2—7:30 a. m.	Recovery

Dry material collected September 6. Sheep only slightly sick.

TABLE VI—*Continued*

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, ozs.	Time symptoms observed	Time of death or recovery	Final result
59	90	11- 3-19	10:30 a. m.	6	11- 3—5:00 p. m.	11- 6—8:00 a. m.	Recovery
		11- 8-19	11:30 a. m.	7	11- 9—7:00 a. m.	11-10—8:00 a. m.	Recovery
		11-12-19	2:00 p. m.	6	11-15 (dull)	11-15—8:00 a. m.	Recovery
Material collected as it had dried in the field. Sheep quite sick.							
10a	100	7-21-19	9:00 a. m.	2			
		7-22-19	10:25 a. m.	2	7-22—12 m.	7-23—10:00 a. m.	Death
120	95	7-21-19	9:30 a. m.	2			
		7-22-19	10:25 a. m.	2			Negative

When animals are poisoned with the narrow-leaved milkweed they are affected for a considerable time, the poison appearing to be eliminated slowly. Because of this slow recovery it was thought that small amounts fed daily might cause an accumulation of the poisonous principle in the animal.

Ewe 37 was fed daily 2 ounces of sun-dried milkweed for six days without showing any symptoms of poisoning. The dose was then increased to 3 ounces for two days. On the following day, 4 ounces were fed without causing any symptoms, and two days later she was fed 5 ounces and became only slightly sick. During the ten-day period she had been fed a total of 27 ounces; yet it was only on the last day, when she was fed 5 ounces, that she showed any signs of poisoning. In all the tests summarized in Table II the feedings of 5 ounces produced symptoms of poisoning. These successive feeding tests of Table VI indicate very clearly that there is little if any cumulative action when the milkweed is fed at brief intervals.

Sheep 59, which had been made very sick with 4 ounces in an earlier experiment, was fed 2 ounces daily for two days; then 4 ounces were fed without producing any symptoms. Two days later, when again fed 4 ounces, this animal was made slightly sick. This feeding test also indicates that there is no cumulative action when small doses are fed on consecutive days.

Three days later, on November 3, Sheep 59, the same animal as mentioned above, was fed 6 ounces of the sun-dried milkweed, which made it quite sick. Five days later it was fed 7 ounces and again it developed symptoms of poisoning. Finally, on November 12, four days later, 7 ounces were fed, the animal again becoming slightly sick. Each of these feedings made the animal sick, but not nearly so sick as the original 4 ounces. The last three feedings were made with a different lot of milkweed material which may have been less poisonous; although when 5 ounces of this lot was fed to another ewe it made her sick for two days.

Animal 10a died when given the second feeding of 2 ounces. This case can hardly be considered as at all typical because the animal was found to have a badly diseased kidney which may have retarded the elimination of the poison and hastened death.

Sheep 120, when fed the same amounts and in a similar way as Sheep 10a, developed no poisoning symptoms and to all outward appearances was normal.

These tests prove rather clearly that there is no cumulative action of the poisonous principle in sheep. The same, it is believed, will hold true for other animals. Rather, they seem to show that there is a

tendency to develop tolerance for the poison. It may be that the slow recovery is due more to the slowness with which the nervous system recovers from the action of the poison than to the poison being retained in the system.

TABLE VII

The Narrow-Leaved Milkweed—The Green Plant Fed to Cattle

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result
15	260	8-11-20	8:00 a. m.	1			Negative
19	270	8-14-20	11:10 a. m.	1½			Negative
15	260	8-13-20	4:15 p. m.	2			Negative
19	270	8-16-20	2:50 p. m.	2½	8-17— 7:00 a. m.	8-17—11:40 a. m.	Death
20	320	8-14-20	2:30 p. m.	3	8-15— 8:00 a. m.	8-18— 8:00 a. m.	Recovery
9	225	8- 9-19	10:00 a. m.	3½	8-10— 8:00 a. m.	8-11— 4:00 p. m.	Recovery
888	211	7-23-19	8:30-11:30	4½	7-23— 1:00 p. m.	7-25— 8:00 a. m.	Recovery
7	195	8-12-19	4:00 p. m.	5	8-12—10:00 p. m.	8-13—10:00 a. m.	Death

The foregoing table made from tests with yearling animals may be briefly summarized for a stockman's use as follows: (1) amounts below 2 pounds are not ordinarily dangerous; (2) amounts in excess of 2 pounds and up to 5 pounds are dangerous; (3) amounts of 5 pounds or more may be reasonably certain of causing death; (4) there is a wide variation in the susceptibility of individual animals, some being poisoned with less amounts than others.

TABLE VIII

The Narrow-Leaved Milkweed—The Green Pods Fed to Cattle

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result
15	260	8-16-20	1:45 p. m.	2½			Negative

This one feeding showed very clearly from the view-point of a stockman that there is no increased danger from an animal eating pods, for (1) it takes a large number of the plans to produce 2½ pounds of pods, a greater number than any animal would graze in any one time; and (2) if 2½ pounds produce no symptoms of poisoning, it is plain that the pods are not especially poisonous.

The following table summarizes the feeding of air-dried narrow-leaved milkweed to cattle. This material was cut green and allowed to dry thoroughly in the sun; the weight when dry being approximately 66% less than the green weight:

TABLE IX

The Narrow-Leaved Milkweed—The Air-Dried Plant Fed to Cattle

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result
48	272	9-24-20	10:00 a. m.	¼			Negative
15	260	8-25-20	1:00 p. m.	¼			Negative
49	298	9-15-20	9:00 a. m.	½	9-16—4:30 p. m.	9-17— 8:00 a. m.	Recovery
15	260	6-15-20	8:00 a. m.	½	6-15—2:30 p. m.	6-16— 8:00 a. m.	Recovery
8	225	10-16-19	4-6 p. m.	¾	10-17—8:00 a. m.	10-17—11:00 p. m.	Death
17	345	6-16-20	10:00 a. m.	¾	6-17—8:00 a. m.	6-18— 8:00 a. m.	Recovery
18	220	7-21-20	5:00 p. m.	¾	7-22—8:00 a. m.	7-23— 7:00 a. m.	Death
31	280	6-14-20	11:30 a. m.	3	6-14—7:00 p. m.	6-15— 7:00 a. m.	Death

For the practical purposes of the livestock business the following conclusions may be drawn from this table for yearling animals weighing around 250 pounds: (1) small amounts of one-fourth pound or less are practically harmless; (2) amounts of one-half pound are dangerous but not fatal; (3) amounts of three-fourths of a pound will either kill the animal or make it very sick; (4) all amounts in excess of three-fourths of a pound are highly dangerous.

Animal 31, through a mistake, was fed 3 pounds of the dried plant mixed with alfalfa. The animal ate this very greedily. This shows that an animal will readily eat much more than a fatal dose of the dry milkweed, especially if it is mixed with a palatable feed such as alfalfa hay. When the plant is dried, it does not lose its poisonous character, but apparently does lose its bad flavor and becomes much more attractive to both sheep and cattle.

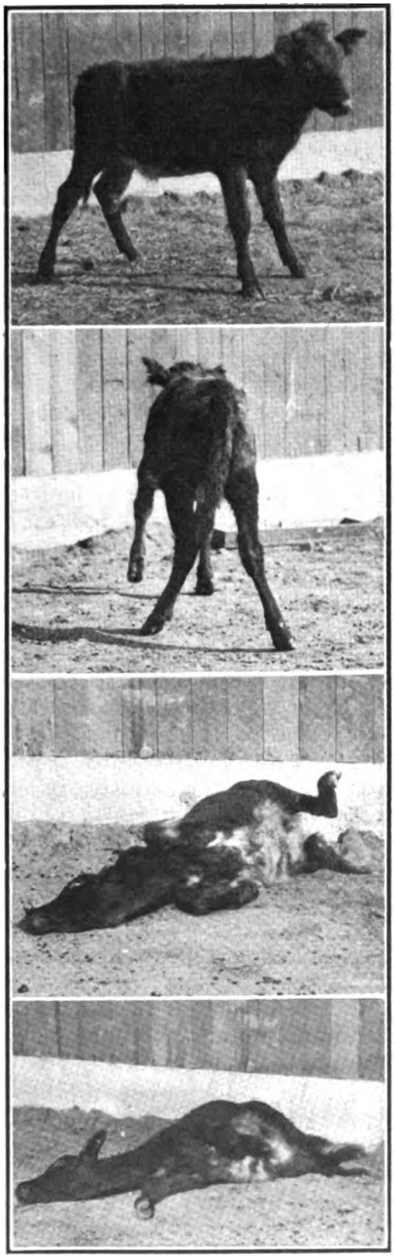


Figure 9—Calf Poisoned by Narrow-Leaved Milkweed.

SYMPTOMS OF MILKWEED POISONING

The first symptom noted in sheep is extreme dullness or entire loss of appetite. In as sluggish an animal as a sheep this abnormal dullness is often difficult to detect, and some of the tests recorded as negative may have had this symptom. In several cases there was a distinct trembling over the entire body accompanied by salivation. The next symptom to appear was a wobbly unsteady gait, first noticeable in the hind legs. In several cases this became worse until the animal staggered and was hardly able to walk, sometimes falling over.

In extreme cases this would be followed by a stage where the animal was down and unable to get up. Some of the animals while down were in a comatose stage as if asleep or in deep stupor.

In the fatal cases there was a series of spasms while the animal was down, much resembling the symptoms of water hemlock (poison parsnip, *Cicuta*) poisoning. While

in this condition the eyes were staring and bleared, the pupils dilated. The head was drawn far back; in many cases there was champing of the jaws and grating of the teeth, with rapid running or kicking movements of both the hind and front legs, followed by spells when the legs would be extended and rigid. Any disturbance of the animal then brought on additional spasms, attended frequently by bleating grunts or groans. In all fatal cases the spasms occurred at irregular intervals until death, spasms becoming weaker and of shorter duration with a longer interval between them.

In nonfatal cases the symptoms during recovery were as follows: If the animal had been down, it would get up but be hardly able to walk, often falling down in its attempt to keep on its feet. As the animal began to get better it would walk with a distinctly unsteady gait and would sometimes refuse to eat for a considerable length of time. Some would eat while still hardly able to walk. The symptoms would disappear so gradually that it would often be very difficult to say definitely when the animals had recovered, just as it was hard to tell when they began to get sick.

The sheep that died were sick from five to twenty-four hours. Those that recovered were sick from twelve to seventy-two hours, most cases from twelve to forty-eight hours. Cattle showed practically the same series of symptoms as did sheep. Those that died were sick twelve to fifteen hours, and those that recovered were sick eighteen to forty-two hours.

Typical Cases

Case No. 1—A sheep weighing 100 pounds was fed 4 ounces of air-dried leaves at 8:40 a. m. on November 17, 1919. The following morning at 8 a. m. she was sick and walked with an unsteady gait. At 2 p. m. she was much worse and was hardly able to get up. By 6 o'clock she was down and unable to rise. She lay flat on her side and appeared to be in a deep stupor until 2 p. m. of the 20th, when she got up, but walked with a very unsteady gait and appeared to have imperfect control of the muscles of one hind leg. She was so weak that she fell down, but soon got up again. Next morning she appeared normal, except that she limped on one hind leg.

Case No. 2—An ewe weighing 115 pounds was fed 5 ounces of air-dried material at 11 a. m. on October 21, 1919. By midnight no symptoms had appeared. At 8 o'clock next morning she was sick and scarcely able to walk. By 11 a. m. she was down and was hardly able to get up. At 9 p. m. she was still sick, and the following day she staggered around when she walked. Next morning, October 23, she appeared to have practically recovered.

Case No. 3—A ewe weighing 85 pounds was fed 8 ounces of dry leaves at 10 a. m. on November 20, 1919. At 2 p. m. she was drooling freely and not eating. By 4:30 p. m. she walked with an unsteady gait, this being especially noticeable in the hind quarters. She continued to get worse, and at 7:30 p. m. could hardly get up, and when upon her feet could walk only a very few steps before she would fall down. By 9:30 p. m. she was unable to stand. Next morning at 8 o'clock she was about the same as when seen at 9:30 the night before. She made several attempts to get up, but each time would fall over. Over the entire body there was a peculiar trembling of the muscles. At 11 a. m. when-

ever disturbed or moved she went into convulsions. At 2:30 p. m. she had a severe convulsion, and died at 2:45 p. m.

Case No. 4—A ewe weighing 65 pounds was fed 1½ pounds of green material at 2:45 p. m. At 8:40 p. m. she was sick. When she attempted to walk it was with a staggering motion. By 8 o'clock next morning she was down on her side, her head drawn far back, eyes staring and bleared, the pupils dilated. At times she would grind her teeth and champ her jaws. Most of the time there was a rapid running movement of the legs, followed by spells when they would be extended and extremely rigid. This series of movements continued until noon. By 2:30 p. m. the spasms had become weaker and of shorter duration, and the intervals between them were longer. At 3:30 p. m. the spasms were very weak, lasting for an instant or two and recurring about every ten minutes. The animal's temperature was then 105.6°. At 4 p. m. the spasms increased in violence, became more severe and were accompanied by bleating grunts. At 4:15 p. m. there was a severe spasm lasting about five minutes, accompanied by champing of the jaws, grinding of the teeth, and foaming at the mouth. The head was frequently drawn far back. These severe spasms continued about every two minutes until shortly before death, which occurred at 4:45 p. m.

The autopsy showed the spleen slightly mushy, the liver soft and friable; all other organs appeared normal. (Brain not examined.)

Case No. 5—A ewe weighing 80 pounds was fed at 2 p. m. January 2, 1919, 1½ pounds of material that had dried naturally in the field. By 9 a. m. she was sick, walked with an unsteady gait, this being especially noticeable in the hind legs. At 8 a. m. the next day she was down and unable to get up, lying flat on her side with legs stretched out. Frequently she would chew at the bedding, and would champ her jaws most of the time. A peculiar trembling of the nose and lips was noticeable. At 9:30 p. m. she was in the same condition, groaning as if in pain, kicking the hind legs and frothing at the mouth. Her temperature at 1:30 p. m. was 103°. She was in this condition until 3 p. m., when she died.

Case No. 6—A sheep weighing 100 pounds was fed 2 ounces at 9 a. m. July 21. The next day at 10 a. m. 2 ounces more were fed. By noon the animal was sick, walking with an unsteady gait. It continued to get worse during the afternoon. Next morning it was unable to get up and had convulsions when disturbed. It soon fell over on its side and had running movements with its legs. It remained in this condition until death, which took place about 10 a. m.

The autopsy at 11 a. m. showed the following conditions: There was an acute cloudy swelling of the right kidney. The left was affected by a chronic disease not caused by poisoning. The liver was friable and highly reddened; blood flowed from cut surface. Some of the lymph glands were hemorrhagic. The brain showed marked congestion of the meninges, especially over the cerebellum and the anterior portions of the cerebrum. Many minute pin-point hemorrhages were found in the gray matter of the brain. These were located in the corpus striatum, corpus callosum, medulla, and medullary portions of the cerebrum.

Case No. 7—A sheep was fed 7 ounces of dry material at 2:30 p. m.,

August 25, 1920. It was found dead next morning at 8 o'clock. The autopsy showed the following: carcass bloated, pupils dilated. There was considerable congestion of the mucous membrane of the fourth stomach (abomasum) and small pin-point hemorrhages in the duodenum. The mucous membrane of the bladder was congested. There was a cloudy swelling of the kidneys. In the brain there was marked congestion of the pia mater, and marked injection of the capillaries of the medulla. Hemorrhages were found in the gray matter of the brain.

Case No. 8—A yearling calf weighing 211 pounds was fed 4¼ pounds of fresh material on July 23, 1919, between 8:30 and 11:30 a. m. At 1 p. m. it was frothing at the mouth, and its breathing was rapid and irregular. These symptoms (perhaps not due to the milkweed) soon disappeared and the animal seemed normal the rest of the day. The next morning it walked with a peculiar, stiff staggering gait. It ate a little when fed. At 6 p. m. it was very weak and wobbly, much more so than in the morning. At 8 a. m. the next day it was much better, but still walked with a stiff unsteady gait.

Figure 10—An Early Stage of Poisoning by Narrow-Leaved Milkweed.

Case No. 9—A yearling calf weighing 225 pounds was fed 3¼ pounds of green material at 10 a. m. on August 9, 1919. At 8 a. m. the next day it was sick and hardly able to get up. When on its feet it was very weak and staggered about. At noon it appeared to be in about the same condition as in the morning. By evening it was much better. Next morning at 8 a. m. it appeared to have quite completely recovered, but at times later in the day it staggered somewhat in walking.

Case No. 10—A yearling calf (195 pounds) was fed 5 pounds of green material at 4 p. m. on August 12, 1919. At 10 p. m. it was slightly sick. Next morning at 8 o'clock it was very sick and hardly able to walk, staggering and falling down frequently. Finally it collapsed and lay on its side, kicking rapidly with its legs. Death occurred at 10 a. m.

In the autopsy slight congestion was found in the fourth stomach and in the meninges of the brain.

Case No. 11—A yearling calf weighing 255 pounds was fed on October 16, 1919, between 4 and 6 p. m., three-fourths of a pound of dry material, which was collected September 6 and air-dried. At 8 a. m. next day it was sick and hardly able to walk. There was marked incoordination of the muscles of the hind legs. At 2 p. m. it was down on its side, with legs stretched out, head drawn far back, eyes rolled up; the animal appeared to be dying. This was followed by periods when it seemed to be getting better, but soon it would have another similar attack. During the afternoon it had a series of such attacks. At 8 p. m. it was still down and unable to get up. At midnight it was found

dead. The autopsy at 9 a. m. October 18 showed slight hemorrhages in the trachea, lungs hemorrhagic, kidneys congested; the heart had severe hemorrhages, both internally and externally.

Case No. 12—A yearling calf weighing 220 pounds was fed three-fourths of a pound of dry leaves at 5 p. m. July 21, 1920, which was all eaten next morning. At 8 a. m. the animal was sick and walked with an unsteady gait. The incoordination was most marked in the hind legs, especially the left hind leg. The back was curved to the right. It kept getting worse during the afternoon, and was found dead next day at 7 a. m. The autopsy at 9 a. m. showed the lymph glands hemorrhagic. There was acute inflammation of the liver and of the bladder. Small hemorrhages were found on the heart. The meninges of the brain were congested in region of the cerebrum. There were minute pin-point hemorrhages in the gray matter of the brain; these were more marked in the left side than in the right. These hemorrhages were located in the corpus striatum and in the medullary portion of the cerebrum and cerebellum.

The Time of the Year When Milkweed Is Poisonous.

All the feeding tests and field observations clearly indicate that this milkweed is poisonous at all times of the year. Animals have been poisoned and killed by plants collected in the spring of the year when they were just a few inches high, and by plants collected at later stages of growth up to the time when they had become fully matured and dried up in the fall of the year. Losses, therefore, may occur at any time when hungry animals feed upon this milkweed.

Prevention of Losses.

There is no known remedy for an animal badly poisoned with this plant. Consequently, to avoid losses it is necessary to understand the conditions under which an animal is most likely to eat a fatal dose. The fresh green milkweed as it grows in the field is not relished by any class of live stock and is eaten only under stress of hunger. This is not the case when it is cut and dried and put up in hay, for it then loses a large part of its disagreeable taste and is quite readily eaten. Thus hay containing this milkweed is always dangerous. On the other hand, ranges or pastures where this plant grows are not always dangerous, providing there is enough grass or other forage to satisfy the animals. Thus the losses occur (1) when hungry animals are being herded along driveways or trails where there is little or no feed for stock; (2) when stock are pastured on overgrazed or very closely grazed ranges supporting this plant; (3) when stock are held in pastures growing this milkweed until all the valuable forage has been eaten; and (4) when stock are bedded on areas where this milkweed is abundant.

Most plants of a poisonous nature contain substances which are distinctly distasteful to live stock. In general it may be said that an animal will first graze plants to which it has been used and whose flavor has been found agreeable. However, in the absence of good grazing it will eat what it is forced to eat in an effort to satisfy its hunger. It has been found that on certain ranges many plants are eaten which on other ranges are but seldom touched by the same class of live stock. Further, it has been observed that an animal in good flesh will not, when hungry, eat offensive plants as readily as poor

hungry animals will. Further, poor half-starved animals are more easily and readily poisoned than when well fed. Thus the condition of the animal determines in a large measure the extent to which it will graze poisonous plants and the probability of serious or fatal poisoning.

THE SHOWY-LEAVED MILKWEED AND OTHERS AS POISONOUS PLANTS

After two years of observation in the field and in the feeding corrals we have good reason to believe that the narrow-leaved milkweed is of far greater importance as a poisonous plant than any other species of milkweed growing in Nevada. For that reason only a few experiments with the other milkweeds have been made at this Station. The following discussion of the other species found in Nevada will give a general idea of their appearance and poisonous properties:

The Showy Milkweed (Asclepias speciosa).

This species of milkweed can be found in many parts of Nevada, but it does not seem to be very abundant anywhere. It requires about the same conditions for growth as does the narrow-leaved milkweed, and they are often found growing together.

Live stock do not like it, and it is eaten only under stress of hunger. Often fields grazed by cattle may be closely cropped, with this milkweed standing untouched.

As a poisonous plant it seems to be much less important than the narrow-leaved milkweed. Figure 4 shows the general appearance of this plant growing in the field.

Feeding experiments were made with (1) the green leaves, (2) the leaves as they had dried up naturally in the field, (3) the seeds, and (4) the pods.

TABLE X

The Showy-Leaved Milkweed—Green Leaves, Pods, Seeds, and Dried Leaves Fed to Sheep

Animal No.	Weight, lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms observed	Time of death or recovery	Final result	Part of plant fed
42	106	9-10	10:00 a. m.	1			Negative	Green leaves
84	108	9-11	9:00 a. m.	1½			Negative	Green leaves
64	99	9-12	10:00 a. m.	2			Negative	Green leaves
100	102	9-14	2:00 p. m.	2			Negative	Green leaves
24	85	9- 6	2:30 p. m.	2½	9-7—3:00 a. m.	9-10—8:00 a. m.	Recovery	Green leaves
33	94	9- 6	11:30 a. m.	2½	9-6—6:00 p. m.	7- 7—8:00 a. m.	Death	Pods
27	81	9-12	4:00 p. m.	[illegible]	9-7—7:00 p. m.	Before 10:00 p. m.	Death	Seeds
46	80	12-16	11:30 a. m.	[illegible]			Negative	Leaves dried in the field
46	80	12-28	10:00 a. m.	1			Negative	Leaves dried in the field

The above feedings seem to show that (1) the green leaves are poisonous, (2) relatively large amounts are required to cause poisonous symptoms in a mature range ewe, (3) the pods alone are poisonous, (4) the seeds are highly poisonous, and (5) the plant dried naturally in the field contains little of its original poisonous matter.

Lambs have been fatally poisoned by grazing upon the tender growth

of this plant in the early spring months when all feed was scarce, but the recorded losses have not been large.

Symptoms of Poisoning by the Showy Milkweed.

The symptoms of poisoning were quite different from those produced by the narrow-leaved milkweed. The first symptom noted was extreme dullness, with a total loss of appetite and a tendency to lie down. In the severe cases the breathing was distinctly irregular, the breath being expelled with a grunt. Spasms were entirely absent and in the whole series symptoms seemed much unlike those produced by the narrow-leaved milkweed.

Typical Cases

Case No. 1—On September 6, 1918, at 2 p. m. a yearling range lamb weighing 85 pounds was fed 2¼ pounds of the fresh green leaves. At 8 a. m. the next day it showed symptoms of poisoning. During the day of September 9 it was still sick. September 10 it appeared to have recovered.

Case No. 2—September 6, 1918, at 11:30 a. m. a ewe weighing 94 pounds was fed 2¼ pounds of green pods. She was sick by 6 p. m. the same day. At 9:30 she was down; the breathing was labored and grunting. No other symptoms were exhibited. The next morning at 8 a. m. she was found dead.

Case No. 3—September 12, 1918, at 4 p. m. a yearling lamb weighing 81 pounds was fed one-half pound of seeds. At 7 p. m. of the same day it was extremely dull, respiration irregular. At 8:30 p. m. it was much worse; the breathing was more labored and each breath was made with a peculiar grunt. At 10 p. m. the animal was dead.

Heart-Leaved Milkweed (Asclepias cordifolia).

This plant is not abundantly distributed in the fields or ranges of Nevada. It occurs only in the mountain valleys, and does not appear to be poisonous.

Five feedings of this milkweed were made to sheep, the amounts fed ranging from one-half pound to 2¾ pounds. None of the feedings so far as could be observed had any poisonous effect upon the animal.

This milkweed can be distinguished from the showy milkweed by its surface being smooth or free from hairs, while the showy milkweed is covered with fine hairs. The base of the leaf is heart-shaped, which is not the case with the showy milkweed. There is little danger of confusing it with the narrow-leaved milkweed.

Prostrate Milkweed (Asclepias cryptoceras).

This species of milkweed is not important as a poisonous plant. It grows sparingly and is not widely distributed. It is a plant with somewhat tough leathery leaves, and its growth habit tends to be close to the ground. It may be disregarded as a poisonous plant of any importance in Nevada. One feeding of 3 pounds at one time was made to a mature sheep which did not seem to be at all injured by this large amount.

SECTION II

Technical Information Concerning the Narrow-Leaved Milkweed

This section is not intended for use by farmers and stockmen: The facts included are for the information of chemists and veterinarians.

SYMPTOMS

The appearance of symptoms of poisoning in sheep by *Asclepias Mexicana* occurred about five to seven hours after artificial or natural feeding of the leaves or whole plant.

Five ounces of the dried plant appeared to be the minimum quantity producing symptoms of poisoning in sheep. Three pounds of the dried leaves appeared to be the minimum quantity producing toxic symptoms in a 250-pound calf, with subsequent recovery.

The first noticeable symptoms in either cattle or sheep are general depression, refusal to eat, and unsteady wobbly gait. The unsteady gait is due to partial paralysis of the hind limbs. Occasionally the paralysis is confined to only one limb. This causes an incoordination in movement, and the animal sways from side to side. Marked muscular trembling is sometimes observed, and in a few hours the animal lies down, refusing to arise. During the period of recumbency tetanic spasms (rigid extension) of the limbs occur at intervals of two or three minutes.

There is no perceptible elevation of temperature. The pulse rate increases with the duration of the attack and shortly before death may attain the rate of 180 per minute, becoming very thready. Breathing is labored and rapid. The head is extended backward and quite rigid. The attack may persist for twenty-four hours, and immediately before death the animal lies in a semicomatose state. In case affected animals recover, the gait is unsteady for two or three days. In some cases incoordinate movements of the hind limbs persist as long as one week after the other symptoms have disappeared.

POST-MORTEM LESIONS

These are not especially characteristic.

Summarizing the observations of post-mortem lesions in sheep and cattle, the following pathological changes were fairly constant in deaths due to ingestion of *Asclepias Mexicana:*

The liver exhibited passive congestion and low-grade cloudy swelling. Kidneys light in color with low-grade cloudy swelling. The mucosa of the abomasum may exhibit congestion of a moderate degree which may be continuous throughout the small intestine. Occasionally marked arborization of the blood-vessels of small intestines is observed.

Occasional subepicardial petechial hemorrhages are observed along the coronary vessels and auriculo-ventricular border. The heart muscle is pale and friable.

The pia mater in cerebral and cerebellar regions exhibited a marked congestion on cut surfaces; minute capillary hemorrhages were observed in the medullary portion of the cerebrum and cerebellum, also in the cropus striatum. The lateral ventricles contained a moderate amount of sero-sanguinous fluid.

Histopathological examination of selected tissues confirmed the observations made at the autopsy. In the brain the hemorrhages were largely from the minute capillary vessels. Occasional interstitial capillary hemorrhages were observed in the reticular tissue between the convolutions of the cerebrum.

The liver exhibited acute parenchymatous hepatitis with passive congestion. The kidneys exhibited low-grade parenchymatous nephritis. Myocardium, acute myositis.

THE ACTIVE PRINCIPLE OF ASCLEPIAS MEXICANA

Several species of *Asclepias* which are physiologically active have been examined chemically, and, from the work done by various experimenters on those investigated, the compounds to which the physiological activity of the plant may be ascribed apparently varies considerably. Glucosides have been found in several species, which act on the animal organism as an emetic. In another species (*syriaca*) a crystalline resinous substance was found which acted as an anodyne and cathartic. Quackenbush reports finding a crystalline glucoside in *Asclepias tuberosa* and *Asclepias cornuti*. March, Clawson, Couch, and Eggleston (U. S. D. A., Bul. 800) have recently reported preliminary experiments on *Asclepias galioides,* a species closely related to *A. Mexicana,* in which they found evidence of the presence of toxic compounds having narcotic properties and also those producing a spasmodic type of intoxication. The active principles were not isolated, but experiments on small animals indicated the presence of toxic material in successive extracts of the dry plant, and gave some idea of the solubility relations of these materials. They found that petroleum ether removed no active material, but that benzol extracted substances which were toxic and produced effects in test animals similar to those observed in poisoning of sheep by the plant. Ether and chloroform extracts from the material already treated with benzol and petroleum ether also were toxic, indicating the possible presence of more than one active principle. Other solvents failed to remove toxic matter from the residue. Evidence of the presence of a minute quantity of alkaloids was obtained; volatile poisons and saponins were not found. Alcohol alone was found to extract all of the toxic material, a part of which was soluble in water producing narcosis, and the part insoluble in water producing poisoning with symptoms typical of range poisoning.

A portion of the material used in our feeding experiments was examined, and results were obtained which were in some ways similar to those reported on *Asclepias galioides.*

A small quantity of the plant was extracted successively with solvents and the amounts extracted by each were as follows:

Benzol	10.55%
Ether	0.64%
Chloroform	0.70%
Ethyl acetate	2.68%
Alcohol	0.46%

Each of the residues from these extractions were administered to guinea pigs by mouth in amounts corresponding in each case to five grams of the dry plant, and all appeared to be nontoxic, except the benzol extract. Thus benzol is capable of removing all of the toxic substances. No reactions were noted in the cases of the materials extracted by the other solvents, the animals appearing normal.

Another small portion of the dry powder was studied by extracting with dilute acid and testing with the general alkaloidal reagents. With each reagent used, indication was obtained of the presence of alka-

loids. No alkaloidal preparations were made for animal experiments. A larger portion of the plant which had been dried was extracted with alcohol by percolation. The alcohol was then removed, and the remaining sirup was evaporated to dryness and extracted repeatedly with boiling water. The aqueous extract so obtained was clear and of a dark-brown color. It had a very sweet taste with a slightly bitter after-taste. The residue from this extraction was a black resinous mass.

The aqueous extract and black residue were administered to a guinea pig by mouth. The amounts given corresponded to 5 grams of the dried plant in each case. The aqueous extract proved to be nontoxic, the animal remaining normal, but the black residue was fatal in three hours. The symptoms exhibited by this animal were the same as those shown by the one to which was given the benzol extract. Apparently, then, the active material of *Asclepias Mexicana* differs from that found in *Asclepias galioides* by Marsh, Clawson, Couch, and Eggleston in that the substance producing narcosis found by them in *Asclepias galioides* is lacking in this plant. It is possible, however, that with doses representing larger quantities of the plant the narcotic effect might be present and more noticeable.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 100 RENO, NEVADA December, 1920

To diminish suffering and loss among domestic animals

THE POISON PARSNIP OR WATER HEMLOCK

(*Cicuta occidentalis*)

A Plant Deadly to Live Stock in Nevada

By

C. E. FLEMING and N. F. PETERSON
Of the Department of Range Management

Assisted by

M. R. MILLER
Of the Department of Chemistry

and

Dr. L. H. WRIGHT and Dr. R. C. LOUCK
Of the Department of Veterinary Science

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

154

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. G. F. Talbot (1931) . . . . Reno
Hon. B. F. Curler (1921) . . . . Elko
Hon. Walter E. Pratt (1925) . . . . Reno
Hon. Mrs. W. H. Hood (1927) . . . . Reno
Hon. Miles E. North (1929) . . . . Reno

OFFICERS

Walter E. Clark, Ph.D. . . . . President of University
Carolyn Beckwith . . . . Secretary
Charles H. Gorman . . . . Comptroller

STAFF

Samuel B. Doten, M.A. . . . . Director and Entomologist
F. L. Bixby, C.E. . . . . Irrigation
(In cooperation with Bureau of Public Roads, U. S. D. A.)
Geo. Hardman, M.S. . . . . Assistant in Irrigation
Charles E. Fleming, B.S.A. . . . . Range Management
Edward Records, V.M.D. . . . . Veterinarian
Lyman R. Vawter, D.V.M. . . . . Pathologist
Madge L. Fink, B.A. . . . . . Secretary to Veterinary Department
M. R. Miller, B.S. . . . . Chemist
Martha Ryan . . . . . . Librarian and Secretary to Director

STUDIES OF POISONOUS RANGE PLANTS IN THE UNIVERSITY OF NEVADA

In undertaking the study of poisonous range plants, the Nevada Agricultural Experiment Station has planned a series of experiments to obtain information upon the following points: (1) the part of the plant which is poisonous, (2) the time of the year when it is dangerous, (3) the kinds of live stock poisoned, (4) the amount which must be eaten in order to cause illness or death, (5) the symptoms shown by the poisoned animals, (6) the conditions under which poisoning occurs, (7) methods of cure and treatment, (8) and methods of preventing poisoning.

In addition, studies are made of the post-mortem conditions shown by the poisoned animal, and of the chemical nature of the poisonous element found in the plant.

The basis of all these experiments consists of long series of feeding tests in which plants are brought fresh from the ranges to the University and are fed to range animals in pens where they are kept under close observation.

This bulletin is a report of the results obtained by feeding the plant known as death camas to range sheep and cattle.

S. B. DOTEN,
Director, Nevada Agricultural Experiment Station.

UNIVERSITY OF NEVADA,
Reno, Nevada, January, 1921.

SECTION I

DEATH CAMAS

Zygadenus paniculatus and *Zygadenus venenosus*

Plants Poisonous to Sheep and Cattle

SUMMARY

Death camas is a common poisonous plant of the sheep and cattle ranges in Nevada.

It is a low-growing bright-green plant related to the lilies and the onions. It comes up in the very early spring from a bulb buried eight inches or more in the ground. The bulb is much like an onion, but it has no onion odor, and is covered with a thin black coating. The leaves are long, slender, and grass-like. When the plants come up they look a little like Indian corn; but the leaf is narrower and more fleshy, and it has a distinct ridge or keel on the under side. At first there appears to be no stem; but later a flower stalk is sent up bearing a long cluster of pale yellow flowers.

The first green shoots come up early in the spring before there is grass on the range; and it is at this season that sheep and some cattle are poisoned.

It takes from one-fourth to one-half pound of the leaves to make a range sheep sick when the animal is confined in a pen; it takes a much larger dose, three pounds or more, to kill a sheep under the same conditions. On the range where sheep are driven hard and have no chance to rest and recover, smaller doses are probably often fatal.

On the whole, however, under ordinary range conditions it must be somewhat difficult for even one sheep in a band to obtain a fatal dose of the death camas leaves; and it is probable that many losses thought to have been caused by death camas were in reality caused by some other plant.

Sheep fatally poisoned by death camas froth at the mouth and slobber freely, and occasionally vomit. They grow weak in the hind-legs and stagger when made to walk. Within a few hours they become very dull and weak, standing with head and ears drooping and the back arched. Later, they go down and thereafter rise with difficulty if at all; becoming gradually weaker and usually dying within twenty-four hours from the time of feeding.

Cattle show much the same set of symptoms; but are apt not to froth at the mouth and drool as much as sheep. When in good condition they vomit so freely that they recover within two or three days.

In our experiments we did not succeed in killing any young cattle with death camas. Doses of three-eighths of a pound to two pounds made the animal sick, but caused prompt and profuse vomiting which brought about a fairly rapid recovery. On the range, death probably occurs only when half-starved cattle eat a considerable quantity under conditions where the system is too weak to throw off the poison or where weak animals, driven hard, are poisoned and get no chance to rest and recover.

There is no known remedy for death camas poisoning; and even if an antidote were discovered, it is not likely that it could be used suc-

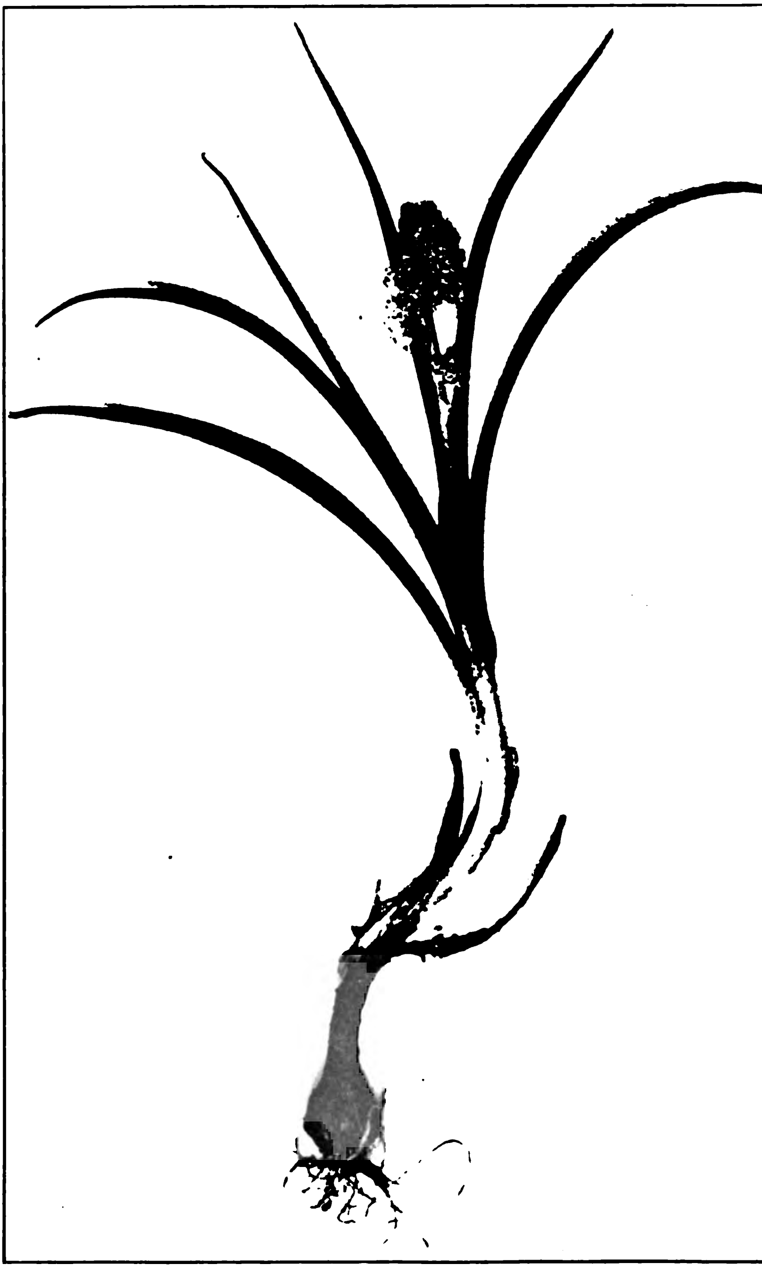


Figure 1. Foot-Hill Death Camas, the Entire Plant, in Bloom.

cessfully under range conditions. Since poisoning occurs only when weak and hungry animals are turned on to death camas ranges where there is no grass or other green feed, and since ordinarily both sheep and cattle will avoid death camas and eat almost anything else in preference, it is evident that the way to avoid poisoning is to keep half-starved animals off death camas ranges and feed some hay until there is grass; and then let the animals scatter out and browse at will, choosing their own forage.

The plants known as death camas have long been recognized as poisonous, being commonly considered as among the most dangerous plants of our western sheep and cattle ranges. Although discussed in nearly all publications dealing with poisonous plants, there is little if any definite information concerning the quantity required to make an animal sick or to cause death; and not much appears to be known about the classes of live stock poisoned, the conditions under which poisoning is most likely to occur, and methods of preventing losses. The experimental feedings and range observations presented in this bulletin were made for the purpose of obtaining exact information upon these points.

Classes of Live Stock Poisoned.

All of the range observations seem to show that more sheep than cattle or horses are poisoned by death camas. No losses of horses have been recorded by the Nevada Experiment Station; and it seems that cattle have been poisoned only when hungry and in poor condition in the spring of the year. Many of the losses on the open range which have been attributed to death camas may in reality have been caused by other plants not known at the time to be poisonous. In fact, a large number of range observations made by the Station show that the probability of poisoning by this plant is by no means so great as is commonly supposed. This side of the matter will be discussed at length farther on in this bulletin.

Common Names.

Death camas is the name by which these plants are commonly known on the range; but they are also called Mystery Grass, Poison Sego, Poison Onion, Lobelia, and Poison Camas.

In Nevada the most common kinds are the foot-hill death camas (*Zygadenus paniculatus*), and the meadow death camas (*Zygadenus venenosus*). The former grows in the foot-hills among sagebrush and other range browse; the latter is more plentiful in moist, grassy places. The foot-hill form is more common in Nevada, being found on most of the ranges in the northern part of the State.

A Description of Death Camas.

The group of closely-related plants known as death camas were formerly included in the lily family; but this family has recently been broken up by botanists who have placed the death camas in the "bunch-flower family" (*Melanthaceæ*).

The plant is erect, producing from two to eight fully formed grass-like leaves. It springs from a layered bulb set from two to eight inches deep in the soil. The bulbs vary in size according to the age of the plant; but they are commonly from one-half to one and one-fourth inches across and are covered by thin, black, papery coats or layers. The leaves are long, narrow, and curved; varying in length from six

to eighteen inches; they are usually less than one-half inch wide; they look a good deal like coarse grass blades with a projecting ridge like the keel of a boat on the under side. They are much thicker and more juicy than ordinary grass blades.

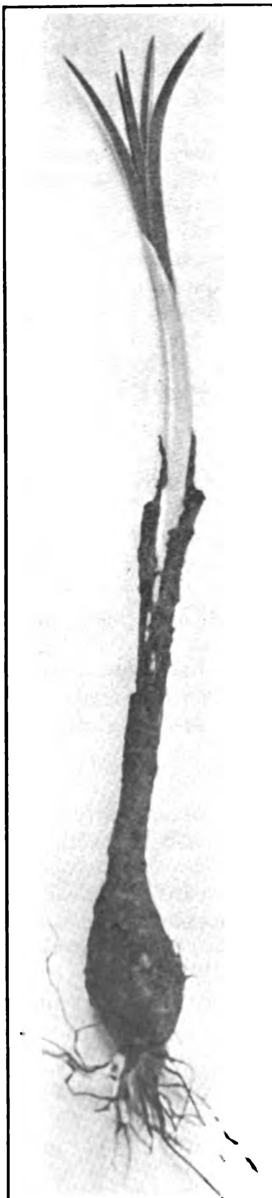


Figure 2. Foot-hill Death Camas, the Young Plant in Early Spring.

There is at first no well-defined stem, the leaves appearing to rise from near the surface of the ground. The flowers are greenish-yellow or whitish, about one-fourth inch across; and are produced in a flower cluster from two to ten inches long. The lower flowers bloom first, and may produce seed pods before the upper flowers bloom. The seeds ripen in the summer; but lie dormant until the next spring, when they sprout and grow into tiny leafy plants. These soon develop small bulbs which may not be any larger than a pea by the end of their first summer's growth. It takes a new plant several seasons to form a bulb sufficiently large to begin to produce flowers and seeds.

The foot-hill death camas differs from the meadow form by having a larger and longer bulb, lying deeper in the soil, usually at a depth of from five to eight inches; while the bulb of the meadow form is smaller and much shorter and is rarely found more than two inches deep in the ground. The foot-hill death camas is also a much larger plant; its flower cluster is branched at the base, while the much shorter cluster of the meadow form is unbranched.

Plants Commonly Mistaken for Death Camas.

Death camas is most commonly confused with the wild onion, although it has no onion odor. When in bloom the two are easily distinguished, for all of the flowers of the onion cluster grow out from the tip of the flower stem, while the flowers of the death camas grow along the sides of the stem as in Figure 4.

Where the Death Camas Grows.

Death camas plants may be found on practically every stock range in Nevada, growing more abundantly in the northern half of the State than in the southern. The ground on which the death camas grows is always quite moist in the spring of the year; and the typical grazing types in which they are found

are: (1) sagebrush, (2) grass, (3) semimeadow areas, and (4) typical weed ranges where the vegetation consists largely of showy flowering plants. They do not grow in the shade under standing timber. They are found on practically all of the mountain foot-hills, the high open mountain park areas, and in the sagebrush country of northern and western Nevada.

The Time of Year When Growth Begins.

The time when death camas starts to grow in the spring varies with the season and also with different exposures and different soils; the green shoots are sometimes found as early as the middle of March.

Figure 3. Foot-Hill Death Camas. Plants in various stages of growth, from seedlings to mature plant in bloom.

The plants make their appearance first on sandy soils and on southern exposures. On the dark loamy and clay soils their growth is much retarded; probably because these soils are moist and consequently warm up less readily. If the weather is fairly warm the death camas will begin to grow from ten days to two weeks after the snow melts out in the spring; and the leaves are soon high enough to cause loss. By the latter part of June on the lower ranges, the plant has usually died down.

How the Flavor of Death Camas Affects the Probability of Poisoning.

All species of death camas which grow in Nevada have a bitter flavor and are extremely distasteful to cattle and sheep. In all our feeding

tests it was practically impossible to get either sheep or cattle to eat this plant readily, even after going hungry for two or three days. When a hungry animal was first fed, a few mouthfuls would be eaten; but almost as soon as the plant juices came in contact with the mouth the animal would begin to wrinkle its nose and move its tongue in such a manner as quickly to get rid of what was in its mouth.

In order to get any large number of plants into an animal it was necessary to resort to forced feedings, which consisted mainly in placing the ground leaves so far back in the animal's mouth that it had to swallow what was given it. When this plant, mixed with palatable

Figure 4. Foot-Hill Death Camas (on left) and Wild Onion. Notice the difference in the arrangement of the flowers on the stem. The flowers of death camas are scattered along the sides of the stem; those of wild onion form a round cluster at the end of the stem.

weeds and grasses, was fed to hungry animals they would sort out the grasses and weeds and eat them, avoiding the death camas wherever possible. This shows clearly how sheep and cattle dislike this poisonous plant and try to avoid eating it.

On many of the grazing ranges in the western part of Nevada, sheep have been closely observed while grazing on ground supporting death camas, with weeds, browse, and a scattering stand of grasses. The sheep nibbled weeds and grasses all around the death camas, leaving it almost untouched. Naturally, no losses occurred under these conditions.

On several of these ranges it was noticed that the death camas plants had been grazed by some animal. A study of conditions on near-by ranges, where it was known that there had been no live stock that season, revealed the fact that a number of rodents, common ground squirrels among others, were eating the leaves and digging up the bulbs. Ordinarily, if there had been sheep on these ranges and poisoning had occurred, it would have been seen that the death camas plants had been grazed; and they would have been blamed for the losses.

A series of similar observations were made on Peavine Mountain, near Reno by J. A. Longyear who states that the tops of death camas plants are nibbled rather freely by ground squirrels.

Because of the fact that in the experimental work it took a large quantity of death camas to kill a sheep, a series of feeding tests were made with the most palatable young green weeds and grasses to find out the amount of such plants a range sheep will eat before its hunger is satisfied.

Two yearling lambs in medium condition were fed a mixture of green

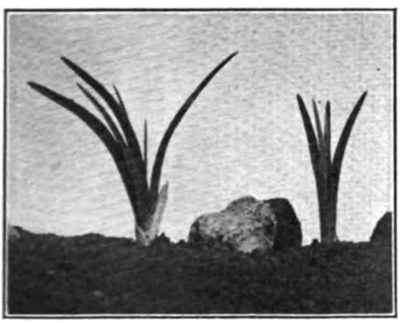


Figure 5. Foot-Hill Death Camas. Plants beginning growth in early spring.

Figure 6. The Foot-Hill Death Camas. This plant has been nibbled by ground squirrels.

grasses and weeds. These animals were fed during a series of days all they would eat in the forenoon and afternoon. The average consumption of weeds and grass was four and one-half pounds on each half-day, or nine pounds per day.

Two old ewes weighing 80 and 90 pounds respectively were put to the same test as the lambs; and it was found that on the average each would eat a little over eight pounds daily. These tests probably show quite accurately the quantity of green feed eaten by a range sheep in a single day.

With death camas the experimental feeding tests showed that the smallest amount which will make a sheep sick is between one-fourth pound and one pound. Amounts of one-fourth to two and one-half pounds in each feeding made the sheep sick; but none died from the direct effects of the poisoning. However, two were so weakened that they died later; one from inflammation and ulceration of the fourth

stomach, the other from pneumonia. Quantities of three pounds or more killed the animals in all cases, with the exception of a single sheep which appeared far more resistant to poisoning than the average animal.

When we compare the capacity of a sheep's stomach, approximately four and one-half of green grass and weeds at a single feeding, with the quantity of death camas required to kill, approximately three pounds or more; then it would appear that the sheep would have to graze very largely on death camas in order to secure a fatal dose.

In order to get a clear idea of how thick a stand of death camas there is on the range early in the spring when the danger is greatest, square-rod plots were laid out where death camas (*Zygadenus paniculatus*) appeared most abundant on the foot-hills southwest of Reno. On April 12, 1918, 32 plants, all that grew on one square rod, were cut off at a height of three-quarters inch above the ground. The total weight

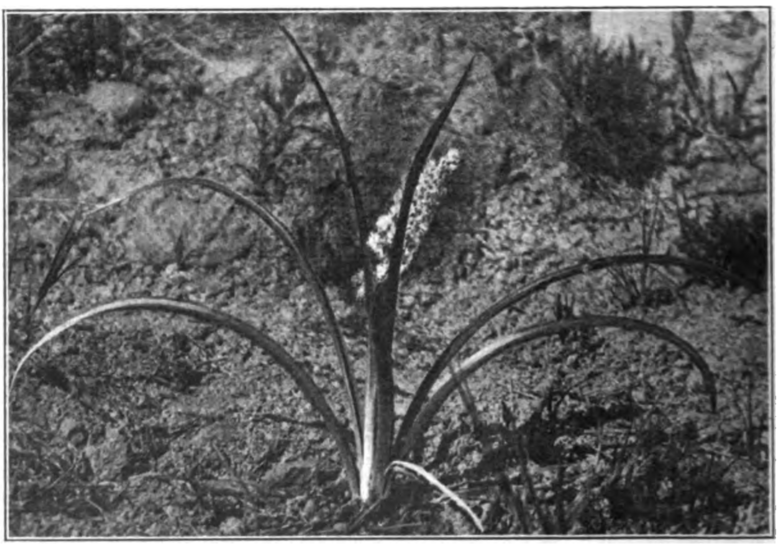


Figure 7. Foot-Hill Death Camas. The leaves appear to spring directly from the ground without any stem.

was 32.8 grams, or a little more than an ounce. On April 15, 52 plants were cut from two square rods and the total weight of leaves cut was 28.6 grams per square rod, or approximately one ounce. At this rate it would take sixteen square rods to produce a single pound of the plant. The leaves at this time were from four to eight inches high.

On all of these plots there was a far heavier stand of death camas than would ordinarily be found on any of the ranges in Nevada. If the plants really grew as thickly on the range as on these selected plots, and if they had reached a height of from four to eight inches, then each acre would produce from 10 to 12 pounds of death camas, enough to poison fatally some three or four sheep. The death camas was cut and weighed at a time of year when all other green vegetation was very scarce, and the likelihood of poisoning was greatest.

On May 17, 1918, when other range vegetation was quite abundant,

17 death camas plants, all that grew on a square rod, were clipped three-fourths of an inch from the surface of the ground; they weighed 4.8 ounces, somewhat more than one-fourth pound. The plants were then in full bloom, some of them going to seed. At this rate and at this time of year an acre would produce approximately 48 pounds of death camas, enough to poison fatally about 16 head of sheep. However, the plant does not grow as thickly as this uniformly over any sheep range. The square-rod plots were selected areas, chosen because they supported an unusual number of plants.

Foot-Hill Death Camas (Zygadenus paniculatus) Feeding Experiments with Sheep.

In the course of the years 1918 and 1919, 69 feedings were made to sheep. Most of these feedings were of leaves, only a few feedings being made of the flower-heads, seed-heads, and bulbs. The results of these feedings are condensed in Table I.

The results of the experiments presented in this table may be summarized as follows:

(1) None of the nine feedings of ⅛ pound each had any appreciable effect upon the animal, indicating that this quantity of the plant is practically harmless; (2) out of the 16 feedings of ¼ pound of the tops, six tests produced no visible symptoms, while 10 made the animals appreciably sick. These feedings show that if sheep in a range flock eat as little death camas as ¼ pound each, trouble may possibly follow.

A single feeding of ½ pound of the bulbs made one sheep sick, but in a few hours it had completely recovered. It takes several plants to make ½ pound of the bulbs, more plants in fact than a sheep could possibly ever pull up; so the bulbs as a poisonous part of the plant may be completely disregarded.

(3) Nine out of 12 feedings of ½ pound of the tops produced typical symptoms of poisoning, while three apparently had little effect upon the animals. A half-pound of the tops will generally make a sheep sick; any larger quantity will almost always cause severe poisoning.

(4) Four out of five feedings of ¾ pound each made the animals sick. These sheep were much more seriously affected than those fed ½ pound each.

(5) Of seven feedings of one pound each, six caused severe poisoning while one had no effect. Apparently one pound is as much as any sheep can eat without danger of serious poisoning.

(6) Four feedings of from 1¼ to 1½ pounds all caused severe but not fatal poisoning.

(7) Five feedings of quantities varying between 1¾ pounds and 2½ pounds caused very severe poisoning, resulting in death in two cases.

(8) All feedings of three pounds each resulted fatally. However, sheep No. 18 was twice fed 3½ pounds without a fatal result, although the animal was severely poisoned and was sick for more than a day each time. This animal appeared to be very resistant to poisoning by death camas; later, in tests with other plants, she showed the same resistance to poisoning.

(9) Three feedings of four pounds of the tops all caused death. It seems fair to assume that under ordinary conditions no sheep can eat such a quantity of death camas and live. Still, four pounds is a far greater quantity than any sheep is likely ever to find on the range.

(10) Of three feedings of quantities of seed-heads varying between

TABLE I

Foot-Hill Death Camas (*Z. paniculatus*). The Fresh Green Plant Fed to Sheep.

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms appeared	Time of death or recovery	Final result
13	69	5-22-18	2:15 p. m.	[illegible]			Negative
8	72	5-22-18	2:20 p. m.	[illegible]			Negative
6	65	5-22-18	2:25 p. m.	[illegible]			Negative
24	67	5-22-18	2:30 p. m.	[illegible]			Negative
28	64	6- 4-18	2:15 p. m.	[illegible]			Negative
27	70	6- 4-18	2:25 p. m.	[illegible]			Negative
26	56	6- 4-18	2:30 p. m.	[illegible]			Negative
25	81	5- 6-18	11:10 a. m.	[illegible]	2:55 p. m.	5:00 p. m.	Recovery
23	79	5- 6-18	11:30 a. m.	[illegible]	3:30 p. m.	5:00 p. m.	Recovery
25	93	5- 9-18	10:20 a. m.	[illegible]	2:30 p. m.	5:00 p. m.	Recovery
25	90	5-10-18	9:30 a. m.	[illegible]	3:30 p. m.	4:30 p. m.	Recovery
21	96	5-10-18	9:40 a. m.	[illegible]			Negative
9	83	5-14-18	11:10 a. m.	[illegible]			Negative
7	71	5-22-18	2:35 p. m.	[illegible]	7:00 p. m.	5-23—10:00 a. m.	Recovery
17	61	5-22-18	2:40 p. m.	[illegible]	8:00 p. m.	5-23— 3:00 p. m.	Recovery
10	82	5-22-18	2:50 p. m.	[illegible]	3:55 p. m.	5-23—10:00 a. m.	Recovery
25	93	5-22-18	2:55 p. m.	[illegible]	3:55 p. m.	7:00 p. m.	Recovery
25	93	5-24-18	9:10 a. m.	[illegible]			Negative
25	93	5-25-18	10:20 a. m.	[illegible]	12:00 m.	3:00 p. m.	Recovery
25	93	6- 4-18	2:35 p. m.	[illegible]	3:50 p. m.	7:45 p. m.	Recovery
14	116	6- 4-18	2:40 p. m.	[illegible]			Negative
26	75	4-17-19	11:45 a. m.	[illegible]			Negative
8	72	5- 6-18	11:00 a. m.	[illegible]			Negative
20	73	5- 6-18	2:40 p. m.	[illegible]			Negative
9	83	5- 9-18	11:45 a. m.	[illegible]	6:40 p. m.	5-10— 8:00 a. m.	Recovery
5	77	5-14-18	11:20 a. m.	[illegible]	2:30 p. m.	5:00 p. m.	Recovery
8	72	5-15-18	10:40 a. m.	[illegible]	1:00 p. m.	5:00 p. m.	Recovery
26	56	5-22-18	3:15 p. m.	[illegible]	4:55 p. m.	10:00 p. m.	Recovery
26	56	5-24-18	9:20 a. m.	[illegible]	10:50 a. m.	11:50 a. m.	Recovery
26	53	5-25-18	10:30 a. m.	[illegible]	2:40 p. m.	8:00 p. m.	Recovery
16	72	5-25-18	10:40 a. m.	[illegible]	1:40 p. m.	3:00 p. m.	Recovery
2	120	6- 4-18	2:50 p. m.	[illegible]	4:50 p. m.	7:45 p. m.	Recovery
29	75	4-17-19	11:45 a. m.	[illegible]			Negative
26	75	4-23-19	11:00 a. m.	[illegible]			Negative
46	69	5- 5-19	10:00 a. m.	[illegible]	4:45 p. m.	7:00 p. m.	Recovery
11	68	5- 7-18	11:30 a. m.	[illegible]			Negative
27	70	5-22-18	3:40 p. m.	[illegible]	7:00 p. m.	5-23— 8:00 a. m.	Recovery
27	66	5-23-18	10:35 a. m.	[illegible]	1:40 p. m.	8:00 p. m.	Recovery
27	66	5-24-18	9:25 a. m.	[illegible]	2:15 p. m.	4:15 p. m.	Recovery
29	75	4-18-19	9:30 a. m.	[illegible]	1:30 p. m.	5:00 p. m.	Recovery
28	64	5-24-18	9:30 a. m.	1	2:15 p. m.	4:05 p. m.	Recovery
28	64	5-25-18	10:40 a. m.	1	12:00 m.	8:00 p. m.	Recovery
10	82	5- 9-18	11:35 a. m.	1	1:20 p. m.	9-11— 8:00 a. m.	Recovery
18	94	5-10-18	11:05 a. m.	1	3:30 p. m.	5:00 p. m.	Recovery
28	63	5-22-18	3:50 p. m.	1	7:00 p. m.	5-23— 8:00 a. m.	Recovery
46	70	4-22-19	10:00 a. m.	1	2:40 p. m.	4-23— 8:00 a. m.	Recovery
29	80	4-23-19	10:30 a. m.	1			Negative
12	75	5- 9-18	11:50 a. m.	1¼	2:30 p. m.	4:30 p. m.	Recovery
24	67	5-14-18	10:40 a. m.	1¼	3:30 p. m.	5:00 p. m.	Recovery
19	68	5- 9-18	10:40 a. m.	1½	1:20 p. m.	6:40 p. m.	Recovery
20	73	5-10-18	11:35 a. m.	1½	3:15 p. m.	5:15 p. m.	Recovery
3	72	5-10-18	10:35 a. m.	1¾	2:30 p. m.	5-11— 8:00 a. m.	Death
16	70	5-14-18	10:15 a. m.	2	2:30 p. m.	5-15— 8:00 a. m.	Recovery
29	65	5-24-18	9:40 a. m.	2	11:05 a. m.	2:00 p. m.	Recovery
19	68	5-16-18	10:15 a. m.	2½	2:30 p. m.	5-18— 8:00 a. m.	Recovery
12	75	5-22-18	10:15 a. m.	2½	12:30 p. m.	5-26—11:00 a. m.	Death
22	83	5-15-18	10:00 a. m.	3	1:00 p. m.	5-18— 9:00 a. m.	Death
5	77	5-22-18	11:20 a. m.	3	12:30 p. m.	5-23— 1:00 a. m.	Death
18	94	5-18-18	10:35 a. m.	3½	1:00 p. m.	5-19— 8:00 a. m.	Recovery
18	94	5-24-18	10:25 a. m.	3½	10:00 a. m.	5-25— 2:00 p. m.	Recovery
20	73	5-17-18	10:15 a. m.	4	11:20 a. m.	5-18— 1:00 p. m.	Death
9	83	5-17-18	10:30 a. m.	4	11:20 a. m.	5-18— 8:00 a. m.	Death
21	96	5-22-18	10:40 a. m.	4	12:20 p. m.	1:25 p. m.	Death
24	67	6- 6-18	2:55 p. m.	[illegible]	11:00 p. m.	5- 7— 6:00 p. m.	*Recovery
29	65	6- 4-18	2:19 p. m.	[illegible]			†Negative
8	72	6- 4-18	2:20 p. m.	[illegible]			†Negative
25	93	5-27-18	10:30 a. m.	1/10	11:30 a. m.	5-28— 8:00 a. m.	†Recovery
29	88	5-15-19	9:40 a. m.	[illegible]			‡Negative
26	81	5- 5-19	9:50 a. m.	[illegible]	4:45 p. m.	7:00 p. m.	‡Recovery

*Flower heads fed. †Seed heads fed. ‡Bulbs fed.

$\frac{1}{8}$ and $^4/_{10}$ of a pound, one caused sickness and two were without result. Apparently the green seed-heads are about as poisonous as the leaves and stems. The number of tests, however, was not great enough to prove this conclusively. As a cause of poisoning in range sheep it is believed that the seed-heads of death camas are of very little importance.

Symptoms of Poisoning in Sheep by Foot-Hill Death Camas.

Small doses, from $\frac{1}{4}$ to $\frac{3}{4}$ of a pound, cause salivation or slobbering in nearly every case. A few cases show nausea and vomiting; there is often a marked increase in the rate of respiration sometimes amounting to panting. The breathing is very irregular; for a time it is rapid, then very slow. In some cases there is a muscular weakness, which is most noticeable in the hind-legs.

With larger doses, from one to two pounds, there is in addition to the above symptoms a period of dullness during which the animal stands with the back arched and the head and ears drooping. With still larger doses the animal becomes so weak as to be unable to rise.

In some cases the mucous membrane of mouth and tongue appeared blue; and two sheep showed such a spasmodic twitching of the muscles as occurs in strychnine poisoning.

Time Necessary for Symptoms of Poisoning to Appear.

The time which elapsed from the time of feeding until symptoms appeared varied from one to seven hours, the average being three hours and ten minutes. The time was slightly less for the larger doses. With doses of less than two pounds the time averaged three hours, twenty-two minutes; with doses of three pounds or more the average was two hours, twenty-five minutes.

Length of Time the Poisoned Sheep Were Sick.

The length of time through which the sheep remained sick was quite variable. After doses of $\frac{1}{4}$ pound to two pounds the animals were sick for from one to eighteen hours, averaging about five or six hours. As several of these sheep recovered during the night, we do not know exactly how long they were sick. Most of the sheep which died from the direct effects of death camas poisoning were sick from twenty to twenty-five hours; and one was down and unable to rise for nearly three days before it died.

Some Typical Cases of Death Camas Poisoning in Sheep.

Case 1. A yearling wether weighing 81 pounds was fed $\frac{1}{4}$ pound of the leaves of death camas at 11:10 a. m. May 5, 1918. At 2:55 p. m. it began to froth at the mouth and made attempts to vomit. The breathing was very irregular, alternately rapid and slow. At 4:30 p. m. the animal seemed to be getting better and by 5 p. m. it appeared to have recovered completely.

Case 2. About one month later, on June 4, 1918, the same sheep, now weighing 93 pounds, was fed $\frac{1}{4}$ pound at 2:35 p. m. At 3:50 p. m. it began slobbering; and at 4:05 p. m. it was nauseated and began to vomit. The breathing was at first fast and shallow, then slow and full, with occasional slight pauses. By 4:30 it had vomited an amount estimated at $\frac{3}{4}$ of a quart. Vomiting ceased soon afterward and by 4:50 the sheep was much better. When next observed, at 7:45 p. m., it was eating hay and appeared to have fully recovered.

Case 3. A yearling wether weighing 56 pounds was fed ½ pound of death camas leaves at 3:15 p. m. May 22, 1918. At 4:35 it was frothing at the mouth and trying to vomit. At 4:40 it was vomiting freely. At 7 p. m. it was still frothing at the mouth, but had ceased vomiting and was getting better. At 8 p. m. it seemed to have recovered. At 10 p. m. it was again slobbering a little. Next morning at 8 o'clock it had fully recovered.

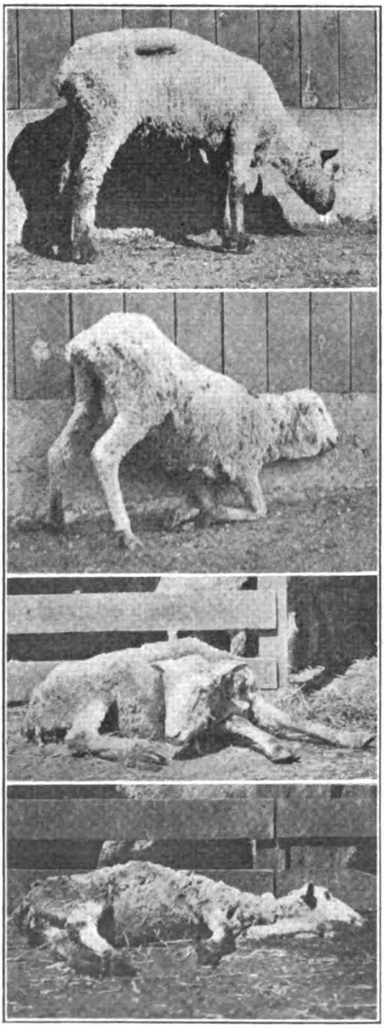


Figure 8. Death Camas Poisoning.

Case 4. A yearling wether fed ¾ pound of the leaves at 9:25 a. m. May 24, 1918, began slobbering a little at 2:15 p. m. This gradually increased, and at 3:20 it was foaming freely at the mouth. At 4 p. m. it was still slobbering a little; but at 4:15 it began eating grass and seemed to have recovered fully. No other symptoms were noted.

Case 5. A ewe weighing 75 pounds was fed 1¼ pounds of death camas at 11:50 a. m. At 2:30 this sheep was grinding its teeth and slobbering freely. At 3:40 it was dull and stood with the head and ears drooping, still frothing freely at the mouth. At 4:30 the animal appeared to have nearly recovered, and was nibbling at feed.

Case 6. A ewe weighing 68 pounds was fed 1½ pounds of death camas at 10:40 a. m. May 9, 1918. It began to froth at the mouth at 1:20 p. m. At about 1:30 it vomited a considerable amount. At 2:30 it was slobbering freely, and stood with drooping head; showing a decided weakness in the hind legs. At 3:30 it was salivating less freely, but still stood with head drooping. At 4:30 it was getting better; but was still slobbering a little, and refused to eat. At 6:40 it appeared to have fully recovered.

Case 7. A ewe weighing 83 pounds was fed three pounds of death camas leaves on May 15, 1918, at 10 a. m. At 1:30 p. m. it was slobbering freely, was weak, and staggered when made to move. The breathing was labored, and at times the animal vomited. These symptoms continued, the animal growing worse until 3 p. m. and becoming weak enough by 4 p. m. to stagger when walking; it was then so weak

that it could easily be pushed over. The mucous membranes of the mouth and tongue were bluish. At 7:30 p. m. it seemed better, and did not appear so weak. At 9 a. m. next day it was down flat on the side and unable to rise. At 11 a. m. it had twitching movements of the muscles similar to those in strychnine poisoning. The animal remained down all that day. Next morning it was still down and appeared to be getting weaker; the breathing was labored and was accompanied by peculiar grunts. At 9 a. m. on the 18th it was found dead, but still warm.

Case 8. A ewe weighing 77 pounds was fed three pounds of death camas at 11:20 a. m. May 22, 1918. At 12:30 it was frothing at the mouth; by 1:30 it was frothing freely at the mouth and vomiting; these symptoms continued until about 2:30. By 2:50 the animal was weak in the hind legs and staggered when made to walk. The animal continued to get worse, and by 4 p. m. was very weak and dull, standing with head and ears drooping and the back arched. At 4:30 it vomited again. At 7 a. m. the animal was very dull, and staggered when made to move. It continued to grow worse until 10 p. m. Next morning, at 8 a. m. it was very weak and unable to get up. It remained in this condition all the forenoon; and died quietly at 1:30 p. m.

Meadow Death Camas (Zygadenus venenosus) Feeding Experiments with Sheep.

Only three feeding tests were made, as the plant is not at all abundant on the ranges in western Nevada; and material for the tests was necessarily limited. It is much less important on Nevada ranges than the foot-hill death camas. The results of the three feedings are summarized in Table II.

TABLE II

MEADOW DEATH CAMAS (*Z. venenosus*). THE GREEN LEAVES AND FLOWERS FED TO SHEEP.

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms appeared	Time of death or recovery	Final result
37	90	6-9-19	9:45 a. m.	½			Negative
37	93	6-11-19	10:50 a. m.	1	1:40 p. m.	5:00 p. m.	Recovery
62	101	6-26-19	11:00 a. m.	2	11:50 a. m.	After 11:00 p. m.	Death

The experiments summarized in Table II show that this plant is poisonous and that amounts of one pound or more will cause serious poisoning in sheep. The symptoms produced by this plant are almost identical with those described for the foot-hill species, as will be seen from the following typical cases:

Typical Cases of Poisoning in Sheep, Meadow Death Camas.

Case 1. A ewe weighing 93 pounds was fed one pound at 10:50 a. m. At 1:40 p. m. it was foaming at the mouth. At 2:40 it was chewing cud, but still foaming at the mouth. At 5 p. m. it appeared to have recovered.

Case 2. On June 26, 1919, a ewe weighing 101 pounds was fed two pounds of the plant at 11 a. m. At 11:50 it was foaming at the mouth and vomiting. At 1 p. m. the respiration was rapid and irregular, varying from 55 to 70 per minute. It still frothed freely at the mouth, the froth being scattered all over the pen. By 4:15 it was very weak, staggered when walking, trying to vomit. The animal then appeared

TABLE III

DEATH CAMAS (*Z. paniculatus* and *Z. venenosus*). SUMMARY OF SYMPTOMS, FEEDING EXPERIMENTS WITH SHEEP.

Species of plant	Z. paniculatus																			Z. venenosus		
Part of plant fed	Leaves													Seed heads		Flower heads		Bulbs		Leaves and flowers		
Dose	1/8	1/4	1/2	3/4	1	1¼	1½	1¾	2	2½	3	3½	4	1/8	1/4	1/16	1/8	1/8	1/4	1/8	1	2
Number fed	11	19	13	6	8	2	3	1	2	2	2	2	3	1	1	1	1	1	1	1	1	1
Number made sick		10	9	5	7	2	3	1	2	2	2	2	3			1	1		1		1	1
Number of deaths								*1		*1	2		3									1
Number showing slobbering		9	9	5	7	2	3	1	2	2	2	2	3			1	1		1		1	1
Retching and regurgitating		2	2	1			1	1	1	1	1	1	2			1						1
Respiration rapid, irregular		6		1	1			1			1		1			1						1
Weak and dull																						1
Weak in hind legs		1	1		1		1	1		1	1	1										
Hardly able to walk																						1
Reluctant to rise		2								1	2	2				1						1
Arching of back					2		1	1			1	1										
Head drooping					1		1				1	1				1						
Ears drooping					1		1	1			1	1				1						
Unable to rise										1	2		1									1
Mouth and tongue blue					1						1		1									1
Twitching of muscles											1		1									

*Death not directly due to zygadenus poisoning.

to be strangling, perhaps due to froth getting into the windpipe. It fell at 4:30 and could not get up again; at 4:45 it got up, but could barely walk. At 7 p. m. it was down and could not be induced to rise. It continued to get weaker and duller until 10:30 p. m., when the observer left for the night. The animal probably died soon afterward; as it was dead, cold and stiff, at 8 the following morning.

A Table of Symptoms of Death Camas Poisoning in Sheep.

Table III gives in very condensed and concrete form the effects of various quantities of death camas (*Z. paniculatus* and *Z. venenosus*) when fed to sheep (see page 18).

Feeding the Green Foot-Hill Death Camas to a Ewe with Suckling Lamb.

Reports from various sources made it seem possible that suckling lambs might be poisoned by alkaloids secreted in the mother's milk when the ewes fed upon this plant, and before the lambs were old enough to nibble at it. To test this matter, a ewe with a suckling lamb was fed the foot-hill death camas under the conditions listed in Table IV.

TABLE IV

FOOT-HILL DEATH CAMAS (*Z. paniculatus*). THE FRESH LEAVES FED TO A EWE WITH SUCKLING LAMB.

Animal No.	Date	Time fed	Amt. fed, lbs.	Weight lbs.	Time symptoms appeared	Time of recovery	Effect on ewe	Effect on lamb
37	4- 1-19	1:30 p. m.	1/8	98			Negative	Negative
	4- 2-19	3:30 p. m.	1/8				Negative	Negative
	4- 3-19	1:30 p. m.	1/8				Negative	Negative
	4- 4-19	1:30 p. m.	1/8				Negative	Negative
	4- 9-19	9:00 a. m.	1/4				Negative	Negative
	4-10-19	8:40 a. m.	1/4				Negative	Negative
	4-11-19	9:00 a. m.	1/4				Negative	Negative
	4-16-19	8:40 a. m.	1/4				Negative	Negative
	4-17-19	8:30 a. m.	[illegible]		11:30 a. m.	4:00 p. m.	Recovery	Negative
	4-18-19	9:30 a. m.	1		10:00 a. m.	11:00 a. m.	Recovery	Negative
	4-19-19	9:00 a. m.	1/2		7:30 p. m.	4-20—8:00 a. m.	Recovery	Negative
	4-22-19	10:00 a. m.	1 1/2		1:00 p. m.	2:00 p. m.	Recovery	Negative

The tests recorded in Table IV show that although the ewe was fed amounts varying from 1/8 pound to 1 1/2 pounds and was made sick four times, still the suckling lamb was not affected during any of the twelve feedings of its mother.

In the case of the ewe these feedings would also seem to indicate that there is little or no tendency for a sheep to become immune to the poisonous effects of death camas after feeding repeatedly upon it.

Feeding Green Foot-Hill Death Camas to Cattle.

Table V summarizes the results of eighteen tests in which the fresh green plants were fed to cattle (see next page).

It appears from this table that cattle are quite susceptible to the poisonous principle of the foot-hill death camas. Out of the eighteen feedings, ten made the animal sick; but no deaths occurred. It was almost impossible to get cattle to eat more than two pounds of the plant; because they soon became so violently sick that they vomited up all the material eaten. Two small feedings of 1/4 pound each had no apparent effect upon the animals fed; but quantities of from 3/8 of a pound to two pounds usually caused symptoms of poisoning. In some instances poisoning was quite severe, reducing for several days the vigor and strength of the animal.

TABLE V

FOOT-HILL DEATH CAMAS (*Z. paniculatus*). THE GREEN LEAVES FED TO CATTLE

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed, lbs.	Time symptoms appeared	Time of death or recovery	Final result
1	137	4- 8-19	8:00 a. m.	[illegible]			Negative
6	203	4-12-19	8:45 a. m.	[illegible]			Negative
1	137	4-10-19	8:30 a. m.	[illegible]			Negative
4	165	4-10-19	9:00 a. m.	⅜	11:30 a. m.	3:00 p. m.	Recovery
4	165	4-15-19	9:00 a. m.	[illegible]	11:00 a. m.	3:30 p. m.	Recovery
4	165	4- 8-19	8:30 a. m.	[illegible]	9:30 a. m.	4:30 p. m.	Recovery
6	203	4-10-19	9:45 a. m.	[illegible]			Negative
1	137	4-12-19	8:30 a. m.	[illegible]			Negative
1	143	4-16-19	9:00 a. m.	[illegible]			Negative
4	150	4-25-19	10:50 a. m.	½	About 12:00 m.	4-26—8:00 a. m.	Recovery
5	208	4-10-19	10:20 a. m.	[illegible]			Negative
5	208	4-16-19	10:20 a. m.	[illegible]	10:50 a. m.	4:00 p. m.	Recovery
5	208	4- 8-19	9:00 a. m.	1	10:00 a. m.	4:30 p. m.	Recovery
5	208	4-12-19	10:00 a. m.	1	11:30 a. m.	4-13—4:00 p. m.	Recovery
6	193	4-16-19	11:30 a. m.	1	1:00 p. m.	4:00 p. m.	Recovery
8	220	4-14-19	10:20 a. m.	1[illegible]			Negative
5	208	4-19-19	10:00 a. m.	1[illegible]	10:20 a. m.	4-22—8:00 a. m.	Recovery
6	193	4-25-19	9:30 a. m.	2	10:00 a. m.	4-28—8:00 a. m.	Recovery

Symptoms Exhibited by Poisoned Cattle.

Slobbering was not so common a symptom in cattle as in sheep, while vomiting was much more common and more profuse. This vomiting made the animals appear very thin until they recovered sufficiently to eat. A rise in the rate of respiration was a common symptom. Severely poisoned cattle became very weak and dull; the gait was unsteady, particularly in the hind-legs, the animals sometimes stumbling with the hind feet. A few were either so weak that they were unable to get up, or else they would fall over when walking. Grinding of the teeth and diarrhea were each observed in a single animal.

Length of Time Required for Symptoms to Appear in Cattle.

The time from the middle of the feeding period until cattle became sick varied from 20 minutes to 2½ hours, averaging about 1 hour and 7 minutes. They remained sick for from 3 to 22 hours, averaging 11½ hours.

Some Typical Cases of Death Camas Poisoning in Cattle.

Case 1. A calf weighing 165 pounds was fed ⅜ of a pound of death camas leaves at 9 a. m., April 10, 1919. At 11:30 it was sick and vomited freely. It remained sick, vomiting frequently, until 1:30. At 3 p. m. it appeared to have recovered.

Case 2. A calf weighing 150 pounds was fed ½ pound of the leaves at 10:50 a. m., April 23, 1919. It vomited between noon and 1 p. m. At 3 p. m. it was lying down and appeared dull. When made to get up it walked with an unsteady gait. At 5 p. m. it was up and eating hay. At 8 a. m. next day it was still slobbering; but by 5 p. m. it had apparently recovered.

Case 3. A calf weighing 208 pounds was fed one pound of death camas at 9 a. m., April 8, 1919. At 10 a. m. it began vomiting and frothing slightly at the mouth. At 11:20 it was breathing at the rate of 94 times per minute. At 2:45 it had stopped vomiting and the respiration had fallen to 34 per minute. The animal was still slightly sick at 3:30 p. m. but was eating, and appeared to have nearly

recovered at 4:30 p. m. At 8:30 next morning it was walking with a peculiar gait, frequently stumbling with the hind feet.

Case 4. A calf weighing 208 pounds was fed 1½ pounds at 10 a. m., April 19, 1919. At 10:20 a. m. it began vomiting, and vomited again at 11:20 a. m. Was grinding the teeth almost constantly from 10:30 until noon. At noon the respiration was 40 per minute. This calf was able to get up at 2 p. m., but walked with a very unsteady gait, especially noticeable in the hind legs. This condition continued until 9:30 p. m. At 8 o'clock next morning it was still weak and looked very thin.

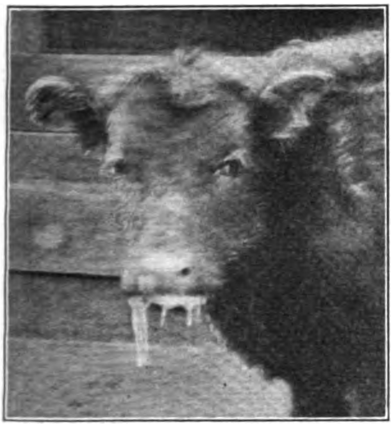


Figure 9. Death Camas Poisoning. This calf shows slobbering after eating death camas. This symptom is more common in sheep than in cattle.

Figure 10. Death Camas Poisoning. This calf shows a common symptom—weakness in the hind-legs.

It ate a little hay, but soon quit; the bowels were quite loose. At 8 a. m. on April 22, it appeared to have recovered; but was still thin and a little dull.

Case 5. A calf weighing 193 pounds was fed two pounds of death camas leaves at 9:30 a. m. At 10 a. m. it began to slobber, the respiration then being 56 per minute. It vomited between noon and 1 p. m. At 3 p. m. it was still dull, and walked with an unsteady gait when made to get up. Next morning it appeared to have fully recovered.

Meadow Death Camas, Feeding Tests with Cattle.

Owing to the scarcity of material, few tests were made with this species. The five feedings made are summarized in Table VI.

TABLE VI

MEADOW DEATH CAMAS (*Z. venenosus*). THE GREEN LEAVES FED TO CATTLE.

Animal No.	Weight lbs.	Date fed	Time fed	Amount fed. lbs.	Time symptoms appeared	Time of death or recovery	Final result
8	220	6-11-19	2:00 p. m.	¾			Negative
9	235	6-11-19	2:30 p. m.	½			Negative
1	138	6-11-19	11:45 a. m.	¾	12:45 p. m.	2:40 p. m.	Recovery
10	330	6-11-19	2:40 p. m.	1			Negative
8	220	6-12-19	8:45 a. m.	1¼	1:00 p. m.	6-13—8:00 a. m.	Recovery

Summary of Results of Feeding Death Camas to Cattle.

Table VII shows graphically the effect of various amounts of death camas when fed to cattle in experimental tests.

TABLE VII

DEATH CAMAS (*Z. paniculatus* and *Z. venenosus*). SUMMARY OF SYMPTOMS, FEEDING EXPERIMENTS WITH CATTLE.

Species fed	Zygadenus paniculatus								Zygadenus venenosus				
Dose	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	3/8	1/2	3/4	1	1 1/4
Number fed	2	3	5	2	3	1	1	1	1	1	1	1	1
Number made sick	----	2	2	1	3	----	1	1	----	----	1	----	1
Number showing:													
Slobbering	----	1	1	----	1	----	----	1	----	----	----	----	----
Regurgitating	----	2	2	----	2	----	1	1	----	----	1	----	1
Dull	----	----	2	----	----	----	1	1	----	----	----	----	----
Unsteady gait	----	----	2	----	2	----	1	1	----	----	----	----	1
Reluctant to rise	----	----	2	----	----	----	----	----	----	----	----	----	----
Respiration rapid	----	----	----	1	1	----	----	----	----	----	----	----	----
Stumbling on hind legs	----	----	----	----	1	----	----	----	----	----	----	----	----
Unsteady on hind legs	----	----	----	----	2	----	1	----	----	----	----	----	----
Fall, and hardly able to get up	----	----	----	----	1	----	----	----	----	----	----	----	----
Grinding teeth	----	----	----	----	----	----	1	----	----	----	----	----	1
Weak	----	----	----	----	1	----	1	1	----	----	----	----	1

Conditions Under Which Death Camas Poisoning Is Most Likely to Occur.

As has been stated, death camas contains a bitter substance extremely distasteful to both sheep and cattle. Consequently the plant is eaten by these animals only under stress of extreme hunger or prolonged starvation.

Most of the cases of death camas poisoning have occurred early in the spring. This is a time of year when all palatable vegetation is scarce, and range animals are often poor and hungry, depending of course upon the way in which they have been handled during the winter. Under these conditions, on a range supporting very little palatable vegetation, hungry animals will eat almost any plant in order to satisfy their hunger. This is well illustrated by a loss of cattle which took place in Elko County.

A herd of cattle were being trailed through sagebrush country where the grass and weeds were just beginning to grow, but where a considerable number of death camas plants had already made their appearance. The cattle were thin and hungry, and at every opportunity they bit off the death camas plants. A rather large number of cattle died as a result of this drive. Some of the poisoned animals that were left behind recovered; those that were driven hard in most cases died on the trail.

In regard to cattle, then, it may be said that the following are the range conditions under which death camas poisoning is most likely to occur: (1) When hungry stock are unloaded from the cars in spring and turned out on a depleted range where death camas is common, and there is very little grass; (2) When cattle are trailed from one range to another in the spring when all palatable feed is scarce; (3) When hungry animals in poor condition are turned out to rustle for themselves in the early spring before the grass is up, so that they are forced to graze any and all plants in order to satisfy their hunger.

When sheep are grazing openly and quietly on a range, they show great care in the selection of the forage they eat. However, when they are being trailed from one place to another, they have no chance to

choose what they will eat, with the result that they eat anything that is not absolutely repellant. If death camas is common, and it usually is, they eat so much of it that they get more of the poison than they can throw off. They are constantly forced to move along on the trail by dogs and herders, and death naturally follows.

Figure 11. Thin and Hungry Cattle on Poor Pasture. Early in the spring animals in this condition are ravenous for green feed. They will then eat death camas or other poisonous plants which ordinarily they would not touch.

Figure 12. Cattle on Good Mountain Pasture. Well-fed animals on good range will ordinarily avoid poisonous plants almost wholly.

It should always be remembered that when a sheep is hungry it usually eats greedily the plant on which it is feeding, or else rushes to another plant for fear some other sheep will get there before it does. But when sheep are grazing openly and quietly, they nip off only the tender and juicy parts of the plant, the leaves and young stems, and carefully select the plants on which they feed.

How to Avoid Death Camas Poisoning in Sheep and Cattle.

Evidently in order to avoid losses on a range where death camas is common, sheep should be so handled that they are never bunched up nor extremely hungry. If they are to be driven from one range to another, it is best to allow them to graze for an hour or two in the morning just as openly and quietly as possible before starting to move them. This will allow all the animals to fill with good forage and they will then use greater care in the selection of their food for the remainder of the day. This would not be the case if they were started on the trail immediately after leaving the bed-ground.

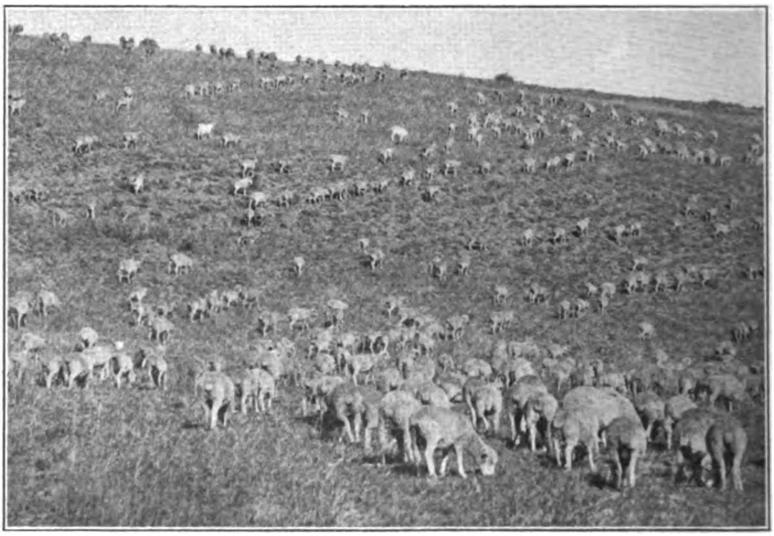


Figure 13. Sheep Grazing at Will on Sagebrush Range. When allowed to feed quietly in scattered formation, sheep will ordinarily wholly avoid death camas and many other poisonous plants.

Another very important point is to get the sheep off the bed-ground just as early in the morning as possible. When a sheep beds down at night it is usually full and contented. By morning it is beginning to get rather empty, and the longer it is kept on the bed-ground the hungrier it becomes; it is then far more apt to be poisoned when it gets out on the range where the death camas is common.

In most of the cases of death camas poisoning thus far observed, the animals were poisoned during the forenoon. This is due to the fact the attractiveness of the plant decreases as the stomach becomes full. Thus plants which may seem to be highly palatable and to be relished during the morning hours are often not touched at all later in the day. This is quite true of the death camas. It is grazed chiefly during the early morning hours, and is seldom touched by an animal whose stomach is nearly full. Therefore it is highly important that the sheep should be so handled during the early morning hours that they will have the greatest freedom in the selection of their range forage; if possible, during this part of the morning they should be grazed on range free from death camas, or where it has only a very scattering growth.

In Nevada the prevailing method of handling sheep, especially in the spring of the year, is to establish a main camp from which the sheep are grazed daily until all the feed in the immediate vicinity of the camp has been eaten out to a distance of two or three miles in every direction. This requires long daily drives back and forth in order to get away from range that has already been grazed. Thus the sheep trail over the same ground each day, until all the forage on the range around the bed-ground has been completely eaten off.

This method of handling can only result in all the plants being eaten, whether poisonous or not; for the most attractive ones are first grazed, and when these are gone the less palatable ones are left to be eaten, including, of course, the death camas.

In order to avoid the losses which result from such improper methods of handling sheep, they should be allowed to bed down wherever they happen to be when night comes. They will then always be on fresh feed in the morning. The variety of forage from which to choose will be much greater; and the probability of poisoning will be far less; providing, of course, that the animals are gotten off the bed-ground early in the morning and are allowed to spread out and graze openly and quietly, each ewe with her lamb. Close-bunched grazing, running, trailing, and massing should be avoided; not only to reduce losses from poisonous plants, but also for the good of the ewe and her lamb, and for the most full and effective use of the range forage.

Remedies for Death Camas Poisoning.

For animals poisoned by death camas there is known at present no practical remedy. The best treatment is to let the poisoned animals entirely alone, disturbing them only when it is absolutely necessary. After an animal has been poisoned it is very much weakened and should be given all the care that is practicable on the range. If it can be kept on good feed and driven just as little as possible for the first two or three days, it will often recover rapidly.

SECTION II

The material included in this section is of greater interest to chemists and veterinarians than to livestock owners.

POST-MORTEM CONDITIONS

Autopsies upon six sheep whose death was caused by death camas in feeding experiments showed the following post-mortem conditions:

There appeared to be no outstanding lesions which would serve to indicate a characteristic effect due to poisoning by this plant. On the whole, the lesions shown were those of a general toxemia. The conditions were such as are found more or less uniformly, with individual variations, after death caused by the ingestion of various toxic or semitoxic plants.

Various degrees of congestion in the gastro-intestinal tract and in its lymphatic system appeared to be prominent symptoms. In some instances the same condition was also found in the kidney, spleen, and liver. The lungs appeared to show no change. In some cases the heart displayed small hemorrhages beneath the epicardium and endocardium, characteristic of toxemia. Considerable quantities of free fluid were observed in the thoracic and abdominal cavities.

THE ACTIVE PRINCIPLE OF DEATH CAMAS

It has long been known that alkaloids are partially, if not wholly, responsible for the poisonous properties of the death camas. Different investigators have studied various species of *Zygadenus*, and the lack of uniformity in the results obtained is not surprising. In the bulk of the work reported it is stated that alkaloids have either been isolated or detected; a single worker found resins in the plant which had poisonous properties. Later attempts to verify these findings in closely related species resulted in failure.

Two physiologically active resins were found by Vejux-Tyrode in 1904 in the bulbs of *Zygadenus venenosus* from Montana. From one of the resins he isolated a basic body which he designated zygadinein and an acid—zygadenic acid. In animal experiments he found the zygadinein to be the active principle. When given in minute doses to guinea pigs, rabbits, and dogs it produced salivation, staggering and respiratory paralysis followed by death, in some cases in a few minutes but usually within a few hours. In 1913 the chemists of the Wyoming Station, F. W. Heyl and F. E. Hepner, investigated *Zygadenus intermedius* for similar toxic resins, but were unable to isolate any toxic substance from the resin or even to establish the toxicity of the resin itself.

The work of early investigators consisted of color tests made upon impure products and led to conclusions that the alkaloids in the species tested belonged to the veratrine group.

In 1903 George Heyl obtained an alkaloid from a California species of *Zygadenus*. The alkaloid found amounted to 0.4%. It was soluble in ether and nearly insoluble in water. Its melting point was 134–135°. It formed a crystalline hydrochlorid.

Alkalodial analyses of *Zygadenus intermedius* were made in Wyoming in an endeavor to determine the quantity of alkaloidal material present in the different parts of the plant. On account of the lack of suitable methods for the determination, the results are probably not so

accurate as might be desired and show only a fair degree of uniformity. Figures for the amounts found in the dried leaf varied from 0.57% to 0.66%; bulb, 0.188% to 0.57%; flower, 1.07% to 1.35%; root, 0.306% to 0.32%.

A quantity of material was prepared and submitted to Dr. Phillip Mitchell and Mr. Geo. Smith for toxicological experiments. The material used in these experiments was not the more highly purified crystallized alkaloid which was reported on later. It was found that when injected intraperitoneally a quantity between 4.6 mg. and 5.1 mg. would produce death in a guinea pig. When administered by mouth a comparatively large quantity was required for fatal effects in the guinea pig. The larger amount necessary was partially accounted for by the fact that the material caused vomiting. In the guinea pig the effects of the material appeared to be the same after subcutaneous or intraperitoneal injection or after feeding.

The mixed alkaloids cause vaso-dilatation and apparently affect the cardio-inhibitory center, slowing the heart action. Respiration was slowed. After doses approaching the fatal quantity the heart-beat becomes rapid and irregular and there is convulsive respiration. In dogs the fatal dose given intravenously stopped the heart before respiration ceased. When either injected or fed, it had a powerful action both as a purgative and an emetic.

Later, in the Wyoming experiments, a more highly purified alkaloid was obtained which could be crystallized from alcohol and benzene. The crystalline material from benzene melted at 200–210° and was found to have the formula $C_{39}H_{63}NO_{10}$. The physiological action was tested by Dr. Phillip Mitchell, who reported its effects to be different from those found for the mixed alkaloids. Its behavior was in general much like the alkaloid veratrine and it required comparatively large quantities to kill guinea pigs. Unlike the mixed alkaloids it had no noteworthy effect on the heart and apparently caused complete loss of muscular control.

In 1918 Dr. C. A. Jacobson of the Nevada Station reported obtaining a new alkaloidal product from *Zygadenus paniculatus*. This alkaloidal product was designated by him as "Z-alkaloid." The crude alkaloid was prepared by extracting the ground and dried plant with 95% alcohol, concentrating the extract to a sirup and pouring into a dilute solution of tartaric acid to remove resins and other impurities. The clear acid solution was further purified by extraction with ether; and the crude alkaloid was precipitated by the addition of sodium carbonate. The precipitate was an amorphous sticky mass poisonous to rabbits. The liquid containing the precipitated solid matter was extracted with ether. It was found that if the ether was completely removed on the water bath, the material would then undergo violent effervescence and the resulting product would no longer be poisonous. If, however, the last of the ether was allowed to evaporate in the air at ordinary temperatures no effervescence took place and the resulting material retained its potency. Further purification was effected by re-solution in tartaric acid, removal of impurities with ether, neutralization and extraction with ether and chloroform.

The more purified Z-alkaloid had an increased toxicity, about 0.35 gram being found to be lethal for rabbits when administered by mouth.

The Z-alkaloid, which constituted about 0.3% of the dried plant, was soluble in ethyl and methyl alcohol, chloroform, acetone, and less so in benzene and carbon tetrachlorid. On standing several months, it resinified to a white substance without change in its toxicity or solubility. On long standing, an alcohol-insoluble crystalline material separated to the extent of about 1% of the original mass, but on account of the small quantity obtained its physiological action could not be determined. Various compounds of the Z-alkaloid were prepared; and from the data obtained it appeared that it is not the same as the compound named Zygadinein which was obtained at the Wyoming station.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 102 RENO, NEVADA May, 1921

HORSE-FLIES AND CATTLE

By

S. B. DOTEN
Director, Nevada Agricultural Experiment Station

This Study was conducted in cooperation with the Bureau of Entomology of the U. S. Department of Agriculture. This Bulletin is based upon observations and notes made in field and laboratory by J. L. WEBB and R. W. WELLS of the Bureau

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

173

NEVADA AGRICULTURAL EXPERIMENT STATION

INTRODUCTORY NOTE

The purpose of this bulletin is to make a report to the farmers and stockmen of Nevada upon the progress of a study of horse-flies which are injurious to cattle at various points in this State.

Each Experiment Station bulletin is written for a certain class of readers; this one is written for use by stockmen and farmers, and therefore does not contain technical descriptions of the insects under discussion nor other similar matter which would be of interest and value only to scientific students of insect life.

Those who desire more complete or more technical information concerning these insects will find it in a paper which will soon be published by the Bureau of Entomology of the United States Department of Agriculture. The field work was done by J. L. Webb and R. W. Wells, under the immediate direction of F. C. Bishopp of the Bureau, with the assistance of students detailed from the University for summer work upon the project and with the cooperation of the writer.

S. B. DOTEN.

SUMMARY

1. On certain ranches in Nevada and eastern California, horse-flies cause great annoyance to cattle.
2. All through the warmer part of the day the cattle bunch together and do not feed, but spend hours in fighting flies.
3. The annoyance of the stock is increased by the presence of the horn-fly and the common stable-fly.
4. In midsummer the cattle in such locations do not put on flesh. even on rich pasturage; and they may lose weight.
5. A number of different kinds of horse-flies share in causing this trouble; but the worst offender is the Western Green-Head Horse-Fly (*Tabanus phænops*).
6. This fly lays its eggs low down in short grass over wet and swampy meadows. The maggots grow to maturity in the soft mud and decaying grass and leaves, ranging through the mud to attack and feed upon other insects and earthworms.
7. In well-drained ground they cannot move about and find their food.
8. Although the flies are often abundant about horses and cattle over alfalfa, the maggots do not develop in alfalfa fields.
9. At present the only hope of control lies in the drainage of wet grass-hay meadows, followed by the planting of alfalfa.

HORSE-FLIES AND CATTLE

HISTORY OF THE PROJECT

For several years past complaints have been received from time to time at the University concerning annoyance and injury to cattle due to horse-flies. Most of the complaints have come from western Nevada; though similar statements have been received from certain livestock owners in the eastern part of the State.

According to these complaints the injury is of the following type: The cattle are so excessively annoyed by the presence of the insects around them and by their painful bites that they bunch together and cease to feed early in the day and spend hours in fighting flies instead of in feeding or resting. On fair warm days when there is little or no wind the cattle may cease to feed by 9 o'clock and may remain bunched up as late as 5 in the afternoon. In fact, it is stated that during the height of the summer the cattle on certain ranches are so pestered by these and other flies that they make no gains on the best of pasturage, and may even fall off in flesh.

The Agricultural Experiment Station of the University was asked to make a study of the horse-flies which cause this trouble and to find out where they breed and whether anything can be done to diminish their abundance. The problem was therefore made a project for study in the Station; and field work upon it was begun in August, 1916, and was continued, except in the winter, until October, 1919.

Because comparatively little was known of the early stages of the American horse-flies, this project promised to be of value to agriculture in other portions of the United States. The Bureau of Entomology of the United States Department of Agriculture therefore took a strong interest in the work; and through the kindness of Dr. L. O. Howard, Chief of that Bureau, the horse-fly problem was made a joint project of the Bureau of Entomology and the Nevada Agricultural Experiment Station.

In August, 1916, Messrs. F. C. Bishopp and J. L. Webb of the Bureau of Entomology visited several points in Nevada and adjacent parts of California to select the most desirable location for the study of the problem. After examining a number of horse-fly-infested regions they decided that the best opportunity for study would be found at Topaz, Calif., the business center of Antelope Valley, a valley which is situated partly in both California and Nevada. With postoffice, general store, and hotel accommodations at hand, this location is in the midst of a heavily infested region. The fields and pastures where the cattle are annoyed lie all around the settlement, the breeding-places of the flies are near at hand; and there is an excellent opportunity for the study of the insects.

Mr. Webb spent the remainder of the summer of 1916 from late in August to the end of October in a preliminary survey of the breeding-places of the flies and in observing their habits and getting information

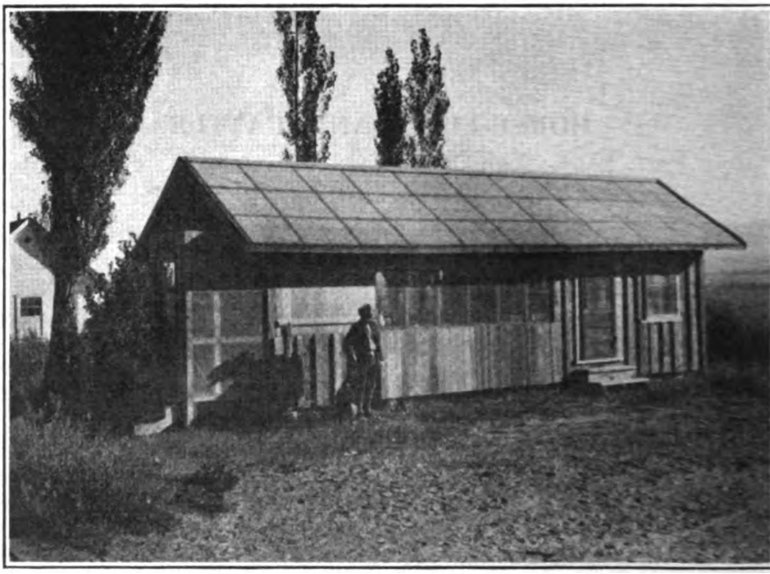


Figure 1. Insectary at Topaz, Calif.
This insectary was constructed by the Nevada Experiment Station for the study of insects injurious to live stock.

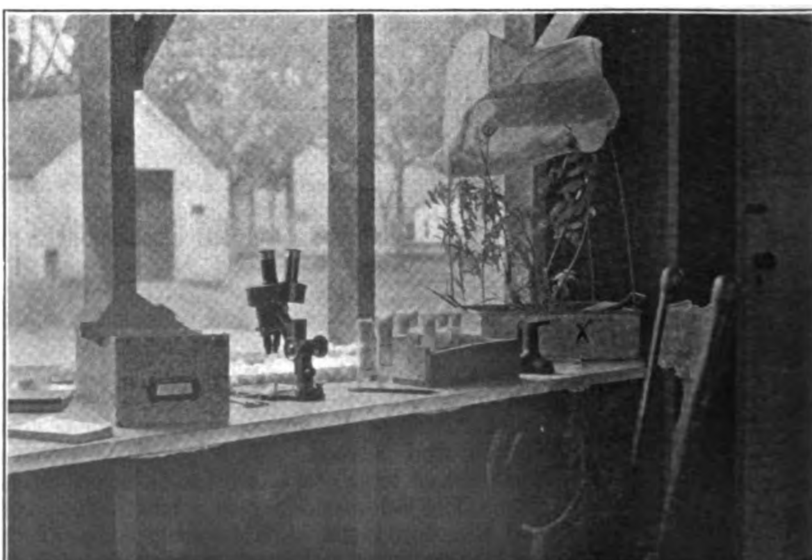


Figure 2. A Corner in the Topaz Insectary.
The openings are covered with wire screen. The conditions in the insectary are much the same as those out of doors. Photograph by J. L. Webb.

concerning their local distribution and the degree of annoyance and injury which they cause.

In May, 1917, an insectary was constructed at Topaz, the structure being made large enough to provide a room for the study of animal diseases. Until October, 1919, the flies were continuously under study.

Mr. Webb was in charge of the insectary at Topaz and carried on the field studies at that point from August, 1916, through September, 1918, after which he received a promotion in the Bureau. This led to the appointment of R. W. Wells, who carried on the studies up to the time when the field work was terminated.

The entire cost of the project was paid from federal funds of the Bureau of Entomology and the Experiment Station; the Bureau furnishing men and some materials, the Station supplying the insectary, paying for supplies and subsistence of men in the field and furnishing student assistants every summer from the University of Nevada.

THE INSECTS WHICH CAUSE THE TROUBLE

Shortly after beginning work at Topaz, Mr. Webb found that the annoyance and injury to cattle are due to the combined efforts of a considerable number of different flies. At least five horse-flies were observed to feed upon the cattle; the common horn-fly (*Hæmatobia irritans*), and the stable-fly (*Stomoxys calcitrans*) were also present and at times proved annoying. A brief description of the appearance and habits of these flies will help to make the matter clearer.

The Horn-Fly (*Hæmatobia irritans*).

This common pest of cattle is a small active insect, a two-winged fly about half the size of the common house-fly and of much the same shape and color. It has the habit of clustering in great numbers about the bases of the horns of cattle. It feeds upon blood sucked from punctures in the skin of the flanks, the udder, or elsewhere on the animal. In some parts of America the horn-fly is so abundant that its annoyance to dairy cattle is a serious matter, for it causes a decrease in the flow of milk. This fly lays its eggs in fresh cow-dung in which the maggots feed and grow to maturity.

The Stable Fly (*Stomoxys calcitrans*).

This is a small gray two-winged fly common about stables. It looks much like the house-fly, but is a little larger. In parts of western Nevada it is common around stables and contributes to the annoyance caused by flies to animals grazing in pastures.

The Deer-Fly (*Chrysops sp.*).

These insects are small active horse-flies belonging to a group with bright colors, mottled wings, and banded eyes. Small as they are, they can bite severely, often attacking man. One will alight so softly on the back of a man's hand, particularly when he is fishing for trout, that it will not be noticed until it suddenly inflicts a most painful bite. The "deer-flies" lay their eggs on leaves growing near muddy sloughs, and their maggots are often fairly common in half-liquid mud near tule roots along such sloughs. On the whole, however, while they annoy cattle to some extent, they are far less important than the larger horse-flies.

The Big Black Horse-Fly (*Tabanus punctifer*).

This insect is fairly common in Nevada and is found throughout western Nevada and adjacent parts of California. It bites severely; and is so annoying to horses that one or two of them buzzing about and biting are enough to set a nervous animal half crazy. On the whole, however, this insect is not nearly so abundant as the Western Green-Head horse-fly. The big black horse-fly lays its eggs on willows, tules, and similar vegetation in the vicinity of pools of water. The maggots which hatch from the eggs live to maturity in the mud along the edges of such pools. Apparently, natural enemies hold this species in check sufficiently to prevent it from becoming abundant and injurious.

The Western Green-Head Horse-Fly (*Tabanus phænops*).

This is the fly which seems to be responsible for most of the annoyance and injury to horses and cattle in the Topaz region and in other parts of Nevada and eastern California where horse-flies are serious pests. For this reason any abatement of the fly nuisance will require first of all the control of this insect. This species, therefore, was given more study than the others, its life-history was carefully worked out in detail; and the conditions of soil and water favorable to its breeding were thoroughly investigated.

Figure 3. The Western Green-Head Horse-Fly, Magnified (X 2). Photograph by the Bureau of Entomology.

Because of the fact that this horse-fly is the only one of the group which causes serious annoyance and injury, the life-histories of the others are not given in this bulletin. They will soon be published in a bulletin of the Bureau of Entomology, United States Department of Agriculture, where further and fuller details of the life-history and habits of the Western Green-Head horse-fly (*Tabanus phænops*) will also be found. The following description of the appearance and habits, the breeding-places, and reproduction of this horse-fly will show the nature of the problem of its control, and will point out the conditions under which it will be possible to diminish its numbers.

Habits. As in the case of other horse-flies, only the females of this species have the blood-sucking habit. The male is inoffensive and is seldom seen. It probably feeds upon the sweet nectar of flowers, for it is unable to bite through the hide of an animal. The mouth parts of the female, however, are expressly adapted to such purpose and readily pierce the hide and enable the fly to gorge itself upon the blood of either horses or cattle. The bite is not poisonous, the actual loss of blood is not very important; but the pain and annoyance are so great that throughout the summer on rich pasturage cattle fail to fatten in fly-infested regions, or even fall off in flesh.

In midsummer in the colder part of the early morning for several hours after sunrise, these flies are not seen, but are resting in grass or alfalfa where they have spent the night. When the sun gets a little higher, they come out and are soon on the wing, flying actively and for

long distances in search of food. During strong winds they do not fly much, but rest in willows or other bushes or in tall grass, resuming flight and feeding when the wind dies down. The females have not been observed about flowers or feeding upon their nectar. They are frequently seen around the edges of pools of water, resting on the mud and drinking.

Appearance of the Mature Female Fly. The fully developed female fly is of medium size, about five-eighths of an inch long, in contrast with the big black horse-fly, the larger specimens of which are fully an inch in length. As with other horse-flies, the head is broad and flat and the eyes are very large. The general color is variable—in some cases dark-brown or almost black; in others a medium brown or even gray. The wings are somewhat smoky in color, the outer margin being brownish; on each side of the abdomen there is an oblong area of reddish brown.

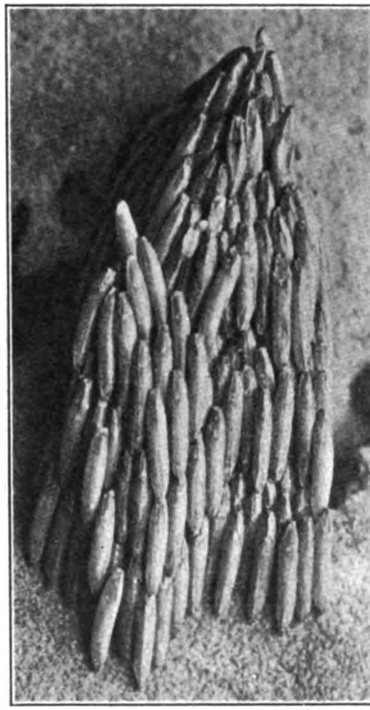


Figure 4. Eggs of the Western Green-Head Horse-Fly, Highly Magnified (X 8).

The Egg. Very great difficulty was experienced in finding the eggs of this horse-fly. Those of the big black horse-fly were more readily found, as the eggs are laid two feet or more above water, and are fairly conspicuous. The Western Green-Head horse-fly, however, deposits its eggs low down in the grass of swampy meadows where there is shallow standing water. To find the egg masses in such localities, it is necessary to search carefully plant by plant and leaf by leaf. To examine completely even a single square yard of sod in this way requires much time and patience. It is impossible in a single day to go over any large area. Still, in spite of these difficulties, Mr. Webb actually succeeded in finding a number of egg masses in open meadows, a fact which sufficiently vouches for his patience and energy.

Each individual egg is spindle-shaped, tapering toward both ends, a little more than one-sixteenth of an inch in length and six times as long as broad. The eggs are pearly white when first laid; but soon become darker, being dark-gray or nearly black when mature. They are laid in masses low down on blades of coarse grass or dry straw in wet and swampy meadows within three or four inches of the mud. It may be that this situation helps to protect them to some extent against attack by other insects. The eggs are laid in a dense wedge-shaped mass about one-third of an inch long. In each such mass there are from 200 to 400 eggs; evidently nature has provided liberally for the perpetuation of this species.

The Maggot. In six or seven days the eggs hatch, all at the same time, and the maggots drop into shallow pools of stagnant water in the wet meadows. As they grow larger they burrow in the mud in such places and frequently are found near the surface in a mixture of half-decayed grass, leaves, and mud.

The newly hatched maggot is pure white or yellowish in color, very slender, tapering and pointed at both ends, about one-sixteenth of an inch long.

The full-grown maggot is slender, cylindrical, about an inch long, and five thirty-seconds of an inch wide. The color is greenish-brown,

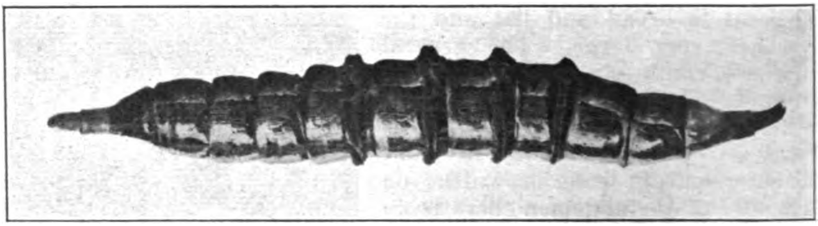


Figure 5. Maggot of Western Green-Head Horse-Fly, Highly Magnified (X 4). Living specimen photographed while fully extended in crawling.

the margins of the segments being darker. The maggot shuns the light and its whole life is spent in soft mud and water where it finds food. The mouth is provided with two strong recurved hooks with which it pierces the skin of other mud-inhabiting insects and earthworms, upon which it feeds.

After it hatches from the egg it burrows in the mud through the rest of the summer in search of food, spending the following winter

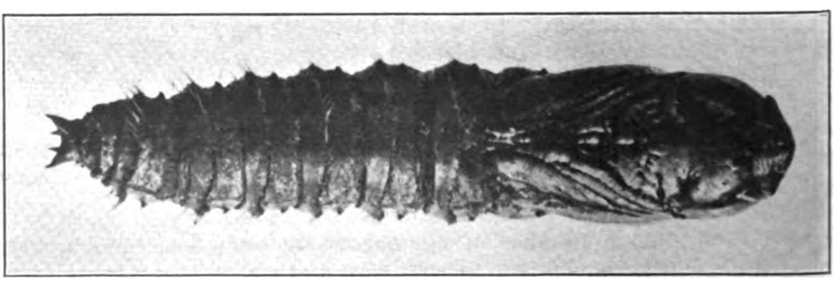


Figure 6. Pupa of Western Green-Head Horse-Fly, Highly Magnified (X 6). In this resting-stage the insect is transformed from a maggot to a fly.

in the same situation. Throughout the warmer portion of the following spring and the early part of the succeeding summer it burrows through the mud in search of prey.

Apparently, if the mud were to become drier it would prevent the maggot of this horse-fly from moving about freely and feeding. Still, it can live for many weeks without food, or with very little food; and the mud in which it lives may become entirely dried out to the cracking-point without causing the death of the maggot. In the fields none of

the maggots have been found in well-drained soil, simply because in such soil they cannot make their way about in search of food.

The Pupa. There is a vast difference in appearance and organization between the maggot and the horse-fly, almost as great a difference as that between a caterpillar and a butterfly. Following the maggot stage of growth there is a resting stage in which there occurs a transformation from a worm-like, mud-inhabiting creature to a winged insect which would perish as soon in the mud as the maggot would in the air. This resting-stage is called the pupa. The accompanying figure shows its appearance better than can any popular description.

The pupa is must like the chrysalis of a butterfly; for there are chambers or cases in which wings and legs are formed, and a jointed worm-like body which encloses the abdomen of the future fly. The pupa is about five-eighths of an inch long and five thirty-seconds of an inch broad. Its general color is dark-gray. It is found in some-

Figure 7. Horses Hooded with Burlap to Protect Them from Horse-Flies. Photograph by J. L. Webb, at Topaz, Calif.

what drier situations than those inhabited by the maggots; perhaps because in the moister locations it might readily be attacked by maggots of the same species, for they are great cannibals. It is, in fact, very difficult to raise more than a single maggot in a jar of wet soil, simply because of their habit of eating one another.

The pupa or resting-stage lasts from two to three weeks in warm weather. At the end of this period the fly comes out and the life-cycle is completed. The sexes then mate and the new eggs are the beginning of the succeeding generation.

Summary of Stages of Growth.

First of all the female lays a wedge-shaped mass of eggs low down on a grass-blade over swampy ground. The eggs hatch in about seven days, tiny white maggots emerging. These maggots drop into mud or water, burrow down in the mud, prey upon other forms of life for a year or more, growing steadily meanwhile. Then they change to motionless pupæ resembling maggots more than flies and remain in

this stage for about two or three weeks. Then the skin of the pupa splits along the forward end of the back, and the fly comes out.

CONTROL MEASURES

The whole purpose of the very thorough investigation made by Messrs. Webb and Wells, assisted by various University students and the writer, was to gain a complete knowledge of the life-history and habits of this insect in order to discover whether at some stage of its growth it might be possible to do something to prevent its further development.

In recent years great progress has been made in the control of insects. Mosquitos are now controlled locally or almost exterminated by coating with kerosene the pools in which the wrigglers live. Even the alfalfa weevil, which has been such a threat to western agriculture, is now controlled inexpensively by spraying with substances containing arsenic. In each instance a knowledge of the life-history and habits of the insect has made it possible to find a stage of growth at which it may profitably be attacked.

Does the life-history of the Western Green-Head horse-fly indicate anything of the kind? Is there any stage of its growth at which it may be attacked successfully? Nothing in the habits of the flies themselves gives any indication of a method by which they may be controlled. At present there seems to be little hope of trapping them in large enough numbers and cheaply enough to diminish the supply. The eggs are safely hidden in the grass beyond direct attack.

Apparently in the whole investigation only one fact stands out which gives any promise of bringing about a decrease in the number of these insects. The one fact which seems to indicate a chance for control is the fact that in all the early part of its life, when the Western Green-Head horse-fly is still a mud-inhabiting maggot, it is incapable of making its way to its food unless the mud is soft and liquid enough to permit the maggot to move about readily in search of other insects and earthworms.

The drying of the soil does not kill this maggot at once; it can endure long periods of drought and can go without food for a long time. Still, if the soil were made permanently moist and well-drained, instead of wet and swampy, then the feeding conditions would no longer be suitable, and the maggots would be able to obtain very little food. Probably the eggs would not be laid by the parent fly over such soil nor would the young maggots develop. This is shown very clearly by the fact that in the localities under study in connection with this project the maggots have not been found at all in alfalfa fields. Such fields and the ditches supplying them with water were searched most thoroughly for weeks without result.

The flies themselves are common enough in alfalfa fields, especially where there are cattle and horses near at hand. This is not an indication that the flies breed in the alfalfa fields, but merely that they are strong fliers and that they can travel long distances away from the wet swampy lands in which the maggots have developed.

On the whole, then, the entire life-history of this insect makes it seem evident that only the drainage and reclamation of wet meadow lands and the substitution of alfalfa for the inferior growth of coarse grass

which such lands now support will lead to any marked decrease in the abundance of the Western horse-flies. Meanwhile, a good deal can be accomplished by putting in a system of ditches which will drain swampy places and do away with sloughs.

In many of the valleys where this insect is troublesome there is talk of reclaiming the wet hay lands by ditching and drainage and by the avoidance of overirrigation. In other similar valleys where all the land

Figure 8. Wet Marshy Meadow Where the Eggs of the Western Green-Head Horse-Fly Are Laid.

had been brought under cultivation and has been put into grain, alfalfa, and potatoes, horse-flies are scarce, and in many such valleys they are even hard to find, being seen only occasionally or at least only in small numbers.

There are so many other reasons for drying out the wet meadow lands and putting them into good hay and crops that the avoidance of horse-flies is only an incidental matter after all, and is merely one more reason for taking a desirable course of action.

AGRICULTURAL EXPERIMENT STATION
THE UNIVERSITY OF NEVADA

Bulletin No. 103 August, 1922

A Revision of Bulletin 94, with Additional Data

ONE-NIGHT CAMPS

vs.

ESTABLISHED BED-GROUNDS

On Nevada Sheep Ranges

By

C. E. FLEMING, B.S.A.,
Head of the Department of Range Management
Agricultural Experiment Station

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

NEVADA AGRICULTURAL EXPERIMENT STATION

ONE - NIGHT CAMPS vs. ESTABLISHED BED - GROUNDS

INTRODUCTION

This bulletin reports the results of experiments and observations carried on through two summers to determine whether it is practical to handle sheep on Nevada ranges without returning each night to an established camp. Figures are also given showing the effect of such a system of handling on the sheep and the range, in comparison with the prevailing method of returning for several nights in succession to the same camp-ground.

The usual method of handling sheep on the summer grazing ranges in Nevada is to drive the herd back each night to the same camp until all the forage within a distance of one to three miles from the bed-ground is eaten out. A new camp is then established. Under this system of handling the sheep are often close-herded; dogs are used more than is good for either the sheep or the range; the range forage is cut up and destroyed by the hoofs; and there is a material loss of flesh in both ewes and lambs.

In order to measure this loss and to show how injury to the range may be reduced, a study of the two methods of herding was made during the summers of 1916 and 1917. This study showed that under Nevada conditions the ewes come off the range in better flesh, the lambs make greater gains, and the carrying capacity of the range is increased, simply by allowing the sheep to bed down wherever they may be at night instead of driving them back each night to the same bed-ground.

Three flocks were studied under each system. The conditions, results, and conclusions of the tests are given below.

THE KIND OF RANGE WHICH WAS STUDIED

In order to make a fair comparison of the two systems, we had first to find a good piece of range which was very much the same all over, and make our trial there. The grasses and plans had to be the same; and they had to be about as thick on one part of the trial range as on the other. The country had to be about the same on one part of the range as on the other, with about the same amount of water on both. The range we selected was an open grassy region, a rolling country where the sheep could get at all of it easily. The grass was about the same on all of it, and the kind of country and the watering-places were very much alike. It was an ideal range on which to try out the two systems of camping.

The forage was made up mainly of grasses, with a scattering growth of weeds and browse. There was very little timber, just a few scattered patches of quaking-ask which were used by the sheep to good advantage for shade during the heat of the day. On an average, about seven-tenths of the surface of the ground was occupied by a growth of plants made up of about 75% grass, 20% weeds, and 5% browse. About 7% of the forage was not utilized. Because the range was so uniform, any differences in carrying capacity can be attributed only to the methods used in handling the sheep.

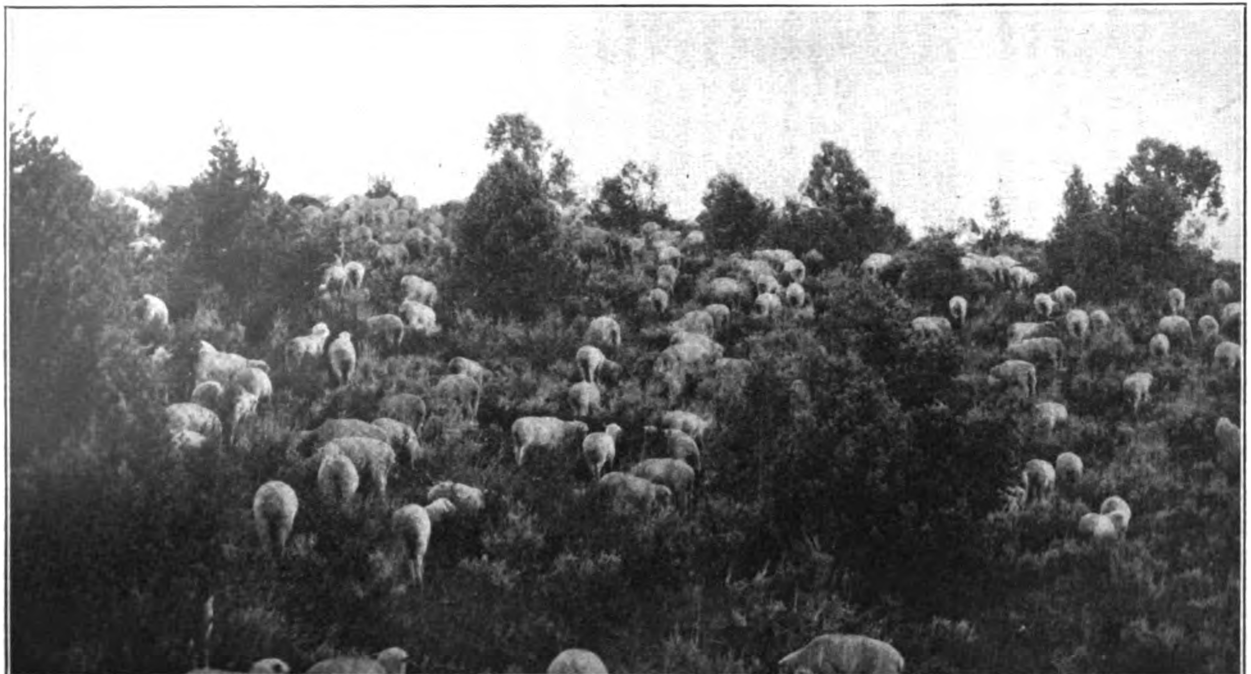


Figure 1. Sheep grazing openly, quietly, and contentedly. Heavier lambs, fewer cripples, and fat ewes will result at the end of the summer grazing season.

THE BREEDS OF SHEEP WHICH WERE UNDER OBSERVATION

The ewes in the bands included in this experiment were mainly fine-wools, with a good many showing the long-wool characteristics of the Lincoln and Cotswolds, or the typical black and brown faces of the Hampshires and Shropshires. However, the foundation blood consisted mainly of Merinos and Rambouillets.

THE HERDING QUALITIES OF THE BREEDS WHICH WERE STUDIED

From all observations made during the two seasons it appears that on the whole the fine-wool sheep are rather more easily herded and handled than the coarse-wools or the mutton breeds.

The sheepmen of western America have not as yet developed a type of sheep fully fitting in with their special needs. They have taken the various breeds which have originated from the individual standards of the breeders, from environment, and from the varying character of climate, forage, and soil, and have adapted them somewhat to meet western economic conditions. Because of this intermingling of breeds, there are but few flocks of pure-bred sheep on our western ranges. Consequently the wool is far from being uniform, the herding qualities vary in different flocks, the lambs produced are decidedly uneven in quality, and the ability to stand severe winters varies according to the breed. To be especially adapted to western range conditions, sheep must have the ability to stand severe storms, with little or no protection, and to maintain themselves on scanty forage during periods of drought and starvation. They must be good shearers, and must have an inbred tendency to herd well, without unnecessary trailing and straying.

The fine-wool sheep therefore do better on our western ranges than most of the other breeds because the environment under which they were developed and produced gave them a permanent ability to sustain themselves on coarse and scanty food.

As rustlers they are entitled to first place. On account of their active rustling habit, they are better adapted than other breeds to the grazing on our rough and broken ranges where they are forced to graze over a large area each day in order to get their food. Moreover, the sheep on our Nevada ranges are kept to an average age of seven or eight years, and the fine-wool breeds will hold their wool better at this age than any other breed. The mutton breeds soon become light shearers, the wool getting especially thin over the stomachs. Of the breeds under observation, the fine-wools utilized the range most efficiently; and their lambs, produced by crossing blocky mutton-bred sires, were the most promising on the range.

THE SHEEPHERDERS

The herders of the bands under observation were Basques. In Nevada practically all of the sheep are herded by Basques. As a general rule, after they are given the proper instructions, they are very reliable and conscientious shepherds. The herders who handled the sheep under observation all showed ability and considerable energy, but they did not all handle their flocks in the same manner. This difference in handling gave an excellent opportunity for making com-

Figure 2. Running the wool and mutton off the sheep. The lazy herder's way of herding. His lambs would weigh at the end of the season from 5 to 7 pounds more if all the unnecessary dogging and running were cut out.

parative tests of range-carrying capacity and of the average daily gains made by lambs under the two methods of camping.

The great difference in the camping methods used by the various herders was that a few changed camp daily and allowed their sheep to graze openly and quietly all the time, while others close-herded their sheep and drove them back each night to the same bed-ground until all the range within a radius of two or three miles was grazed off closely. Then the camp would be moved by the camp-tender and a new bed-ground would be made on another part of the range. A comparison of the effects of the two systems will be given below.

THE ESTABLISHED BED-GROUND SYSTEM

When sheep are handled under this system a main camp is set up and the herd is driven back to it each night and bedded down. On this bed-ground, with the herder, they remain all night without attention until early morning. Then they become restless, because their stomachs are empty and they are anxious to begin feeding. The herder must now be on duty to drive them out to the part of the range where he wants to have them graze during the day.

ONE-NIGHT CAMPS OR THE BEDDING-OUT SYSTEM

Under the system just described the sheep return to the same bed-ground for several nights; but with the bedding-out or blanket system of grazing they bed down on new ground each night. Occasionally the camp cannot be moved because of wet or stormy weather; but under Nevada conditions there are very few stormy nights during the summer and it is generally easy enough to make a new camp every night.

Under this system of one-night camps the range close to the camp is not grazed off completely and injured or ruined, but is left in good condition to be grazed again at a later date. The sheep are always on fresh feed, and this allows them to graze during the cool morning and evening hours and to seek the shade during the hot part of the day.

In the morning as soon as the sheep leave the bed-ground, they begin to spread out; some going in one direction and some in another. Some travel fast and others more slowly. In a short time if they are not checked they will have spread over a large area, and instead of being in a compact band, as they were when they left the bed-ground, they will have commenced to separate into smaller bunches.

As soon as the sheep begin to scatter, a lazy herder or one who prefers the close-bunched herding system will begin to use his dogs and will soon have the sheep rounded up again into a more or less compact bunch. Dogging, running, and trailing go on all day until the sheep have been driven back at night to the bed-ground. Thus an indifferent herder will use his dogs constantly in order to keep the tail-end of the herd up with the leaders; but an energetic and conscientious herder will himself keep moving around the outside of the flock, constantly turning or retarding the leaders. This permits all the animals to graze contentedly, with the best possible chance to choose their forage. The sheep bed down wherever they may be when night overtakes them.

If the heaviest lambs are to be produced from a given piece of range, the system outlined above must be used. The fact is that the ideal method of handling sheep on the range should come as close as possible

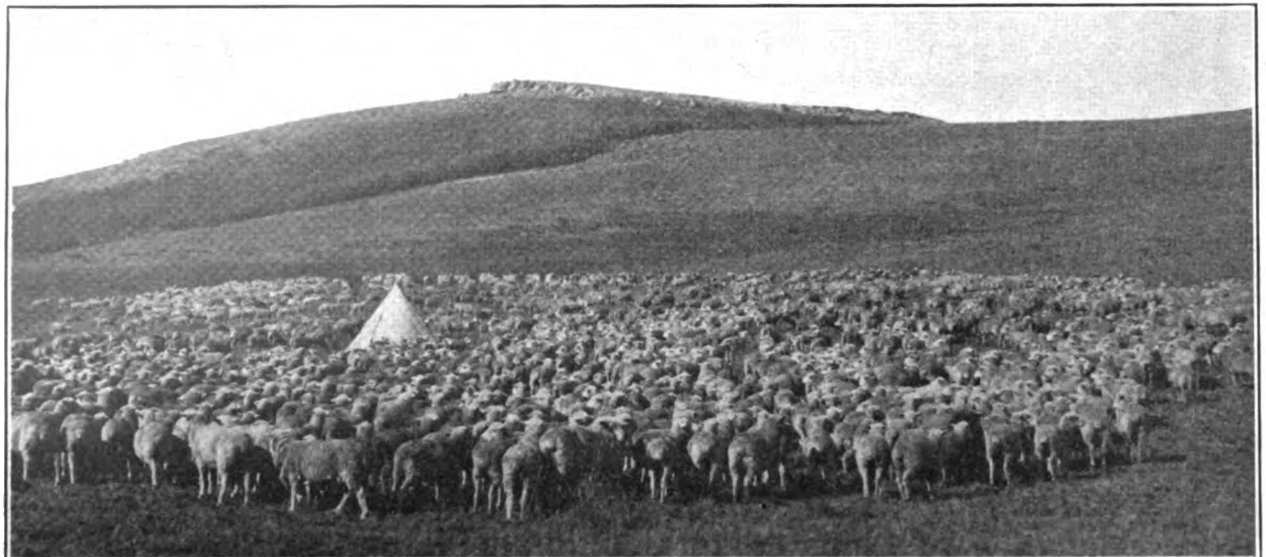


Figure 3. Sheep ready to bed down at evening on a new bed-ground. If the bed-ground is changed daily, the lambs will grow more rapidly, and the range will not be abused.

to the way in which sheep graze naturally on pasture, where the animals do little or no trailing from one place to another and where they are allowed to graze openly and quietly all the time without being disturbed. Of course, it is impossible to handle sheep on the range under fence, under the present conditions on the open public range; but the pasturage system is the ideal and should be approached as closely as possible. This means that tail-end herding must be done away with and the band must be herded from the sides and front, the herder continually turning back the fast-trailing leaders. The slow-grazing sheep which are feeding in the rear of the flock will not then have to keep up with the more active leaders in the band. This gives all the animals an equal chance to fill in the shortest possible time.

This is by no means a lazy man's way of herding; but it will result in an increase in the carrying capacity of the range and will bring about the production of heavier range lambs, fatter ewes, and fewer cripples. It simply means grazing with the smallest possible amount of herding or actual driving. It allows the sheep to graze all through the cool morning hours and to "buck up" during the heat of the day. It permits them to graze with quiet natural freedom, and favors the heaviest production of wool and mutton.

THE EQUIPMENT NECESSARY UNDER EACH SYSTEM

Under the old system of returning to an established camp each night the herder is usually supplied with two tents. He uses one for cooking and for storing supplies; he sleeps in the other. Frequently, however, the cook tent is very close to the bed-ground, so that he may use it if he wishes for cooking, storage, and sleeping. Generally he is not supplied with any means of transportation, depending entirely upon the camp-tender to do all of the moving of his camp supplies.

When the bedding-out system of one-night camps is used, the herder must have a horse or a burro on which he can lash his tent, bed, and provisions every day for transportation to the newly established bed-ground. A burro will carry the average summer-weight bed all day and never feel any discomfort; and, further, he will graze as one of the sheep. He is a very hardy, inexpensive animal and will graze on almost any area where sheep will feed. On some ranges the herders carry their beds on their backs to the new bed-ground. However, on most ranges it will pay a lot better to have a burro.

The most practical tent for the herder is a tepee. In heavy storms it gives the best protection, and when transported it is very easily taken down and set up. It is light in weight and not at all bulky. Probably the most convenient way of carrying bed and tent is simply to take down the tepee in the morning, lash it on the burro, turn him loose with the sheep, and let him graze along with them until they are ready to bed down for the night. A few herders prefer to wait until the sheep are almost ready to bed down; they go and get the tepee from the old bed-ground and put it up where the sheep are to bed that night.

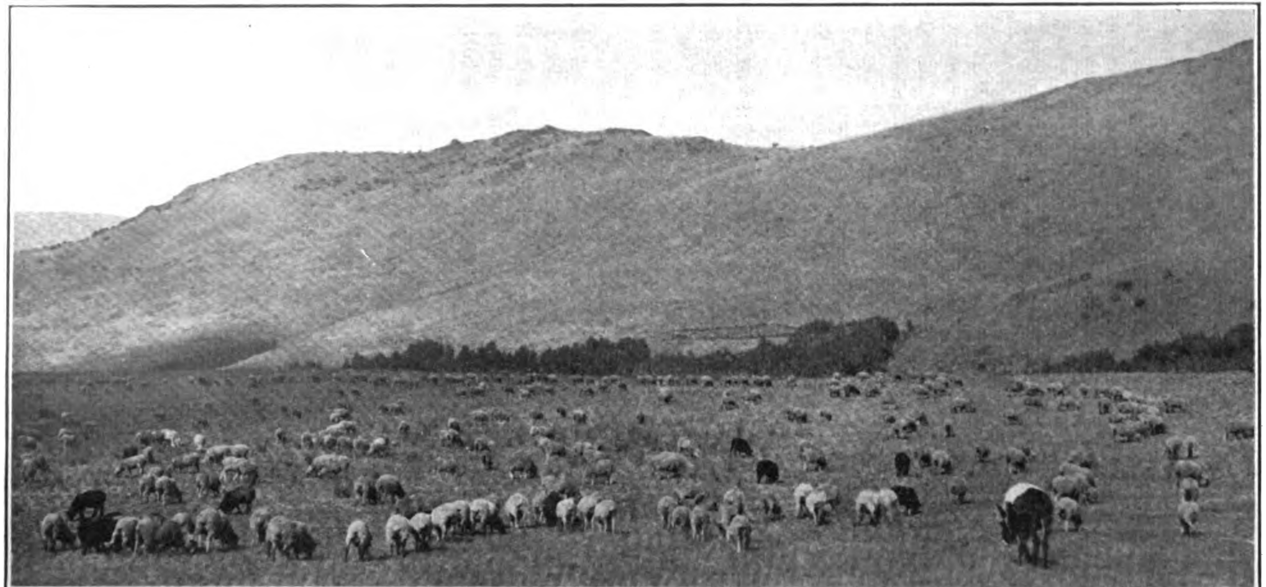


Figure 4. All day the burro carries the bed and tepee, grazing as one of the flock. At night the burro, the sheep, and the herder bed down wherever they are on the range. Open grazing and one-night camps mean increased profits to the owner, more mutton and wool for the Nation, and little abuse of the range.

THE TIME REQUIRED TO CHANGE THE HERDER'S BED FROM ONE BED-GROUND TO ANOTHER

The actual time required to take down a herder's tent and lash it on the back of the burro varies, but with the experienced herder it should not exceed much more than ten minutes. It can be done in less time than this; but for several mornings this was the average time for one herder who was not hurrying. It takes a little longer to take the tepee off the burro, spread it on the ground, put it up, and make the bed. However, the entire operation of changing the bed from place to place should not take more than thirty minutes. During most of the time in summer, when there is no danger from storms, the tepee is not set up, the herder merely using it as a canvas protection to his bed.

THE TIME CONSUMED IN TRAILING TO AND FROM AN ESTABLISHED CAMP

Under the system of returning to the same bed-ground for several nights the herder is forced to trail his sheep for long distances, getting them to fresh feed each morning and then back again at night to the bed-ground. In actual time, it took a herder, who had been at the same camp for six days, one hour and twenty-five minutes to return his sheep to the bed-ground; on the seventh day it took him one hour and thirty-five minutes; on the eighth day one hour and thirty-eight minutes, and on the ninth day the camp was moved.

It took him much longer to get the sheep on fresh feed in the morning than to return them to the bed-ground at night because they had to graze at first for a long distance on range which they had eaten off before, and they traveled very slowly. However, as soon as they commenced to fill they trailed much faster, and soon reached fresh feed. The above figures approximate the average time consumed in the trailing to and from an established camp for a number of days in succession. The long trail each morning and night works the greatest hardship on the sheep because they graze but little on poor range just at the time when they are most anxious to feed. In the evening the herder is usually very anxious to get back to camp and to cook his supper, and he consequently trails them in just as rapidly as possible by whistling, shouting, and the use of his dogs.

For range sheep, more especially lambs, to make the best gains, they should be allowed to graze during the cool evening and morning hours. This is not done when they are forced to trail over range which has already been grazed, as is always the case when the established bed-ground system is used. If they are not forced to make the long daily trail to and from an established camp, the general result will be a material increase in the carrying capacity of the range and a marked increase in the growth of the lambs.

SALTING SHEEP ON THE RANGE

Too much emphasis cannot be placed upon the importance of giving the sheep a regular and liberal supply of salt. When the sheep are returning each night to an established camp it is comparatively easy to put sufficient salt at one time on the bed-ground to last them for five or more days. However, even under this system, some herders do not salt their sheep more often than once a week, which is entirely too

seldom. The best results are obtained when the sheep are given a little salt each day. When the camp is being moved daily this is more or less impracticable. Notwithstanding, they should be salted every three days. This will, in most instances, keep their appetites normal. As soon as sheep become salt-hungry they grow restless and will eat many plants that normally they will not touch. A perverted taste is developed, and, of course, with this abnormal taste many losses from poisonous plants occur which could have been avoided had the sheep been salted regularly. The best salt to use is fine table salt; next to this the crystalline dairy salt. The rock salt is very unsatisfactory, for the reason that it takes a sheep a long time to get an amount sufficient to satisfy his wants, and it is very hard on the teeth of sheep.

There are several ways of distributing salt to sheep on the range. One of the most common is to scatter the salt in several small piles,

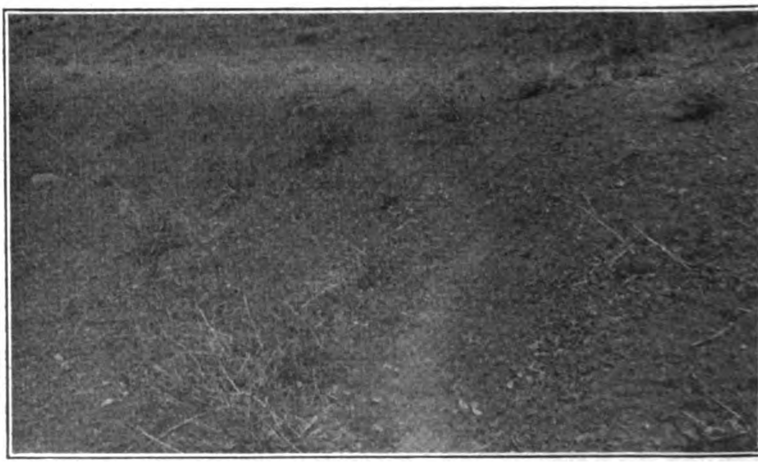


Figure 5. Sheep, when returned to an established camp night after night, eat off and destroy all forage in the immediate vicinity of the bed-ground. Note all that is left is rocks, sticks, and trails. Is it any wonder that the range is being ruined?

fifty to a hundred in number, on the bed-ground, the number of piles depending on the size of the flock. This will give all the sheep a chance to get at the salt without unnecessary crowding and will allow each sheep to get the proper amount. A much less common way is to have five or six galvanized tubs which will nest in each other (Figure 6). These tubs waste no salt, and are light and easily transported. An excellent way of salting on the range to reduce the loss of salt is by the use of canvas troughs as shown in Figure 7. These are made by sewing 12- or 14-oz. canvas to form a trough approximately twelve feet long, nailed to wooden end-pieces. These troughs are then stretched and anchored to the ground by means of stakes as shown in the illustration, or by means of a steel stake which is attached to the end-pieces and driven into the ground, making stationary the lower part of the trough, while the upper part is made solid by means of small guide ropes. A considerable amount of salt taken to the sheep

camps is wasted on the salt-grounds. After salt has been transported long distances by wagon and pack-horse it becomes quite expensive. The loss may be very largely avoided by the use of simple devices such as those described.

When sheep are given salt at long irregular intervals, too much is eaten at once, upsetting the digestion and causing scouring. In several flocks under observation the best results were obtained when the sheep were given one-half ounce daily—that is, three pounds to every hundred sheep. The sheep actually consumed this amount daily, and these figures do not take into account any waste. If the animals are salted in such a way that part of the salt is lost, then a larger quantity per head must be supplied. The foregoing figures are very easy to remember, and show the actual amount which should be consumed daily per head on the range in order to keep the appetites normal and

Figure 6. These small tubs nest each in another. They save salt and are easy to carry.

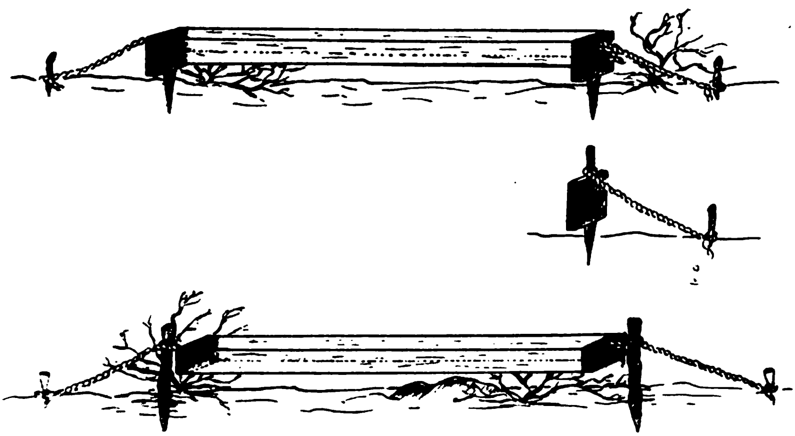


Figure 7. Portable canvas salting-troughs for sheep.

to make the largest daily gain in flesh from the range forage consumed. This is the smallest amount that they should receive when grazing on the open range.

THE EFFECT OF SHADE ON THE GROWTH OF THE LAMB

Good summer management of sheep demands that the ewes and lambs shall be so handled that the greatest possible growth in the lambs is made with the least damage to the range. One of the important factors affecting the rapid growth of lambs is shade during the long hot summer days.

It is not possible to reserve shaded areas on every summer sheep range for the hot days of July and August. Whenever it is possible, however, the forage along the creek bottoms, among the patches of quaking-asp, and the open timbered areas should not be grazed off

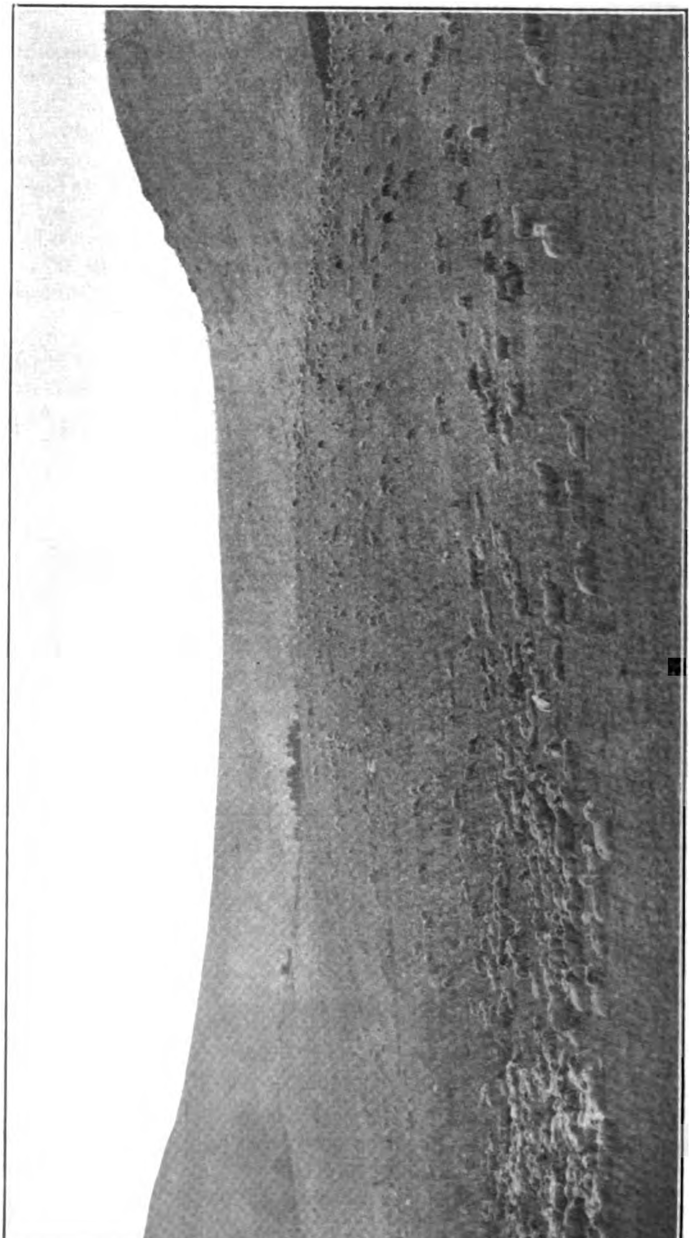


Figure 8. Ideal system of herding on the range. Some are standing, some lying down, others quietly grazing. This means that more sheep can be grazed on a given area and more wool and mutton produced.

first, but should be reserved for the hot weather when it is most needed.

The importance of such management is clearly shown in the fall weights of three flocks of ewes and lambs, which we will call A, B, and C. Flock A was grazed on a range abundantly provided with shade; flock B on a partially shaded range, and flock C on a range entirely free from shade, but well supplied with water and green forage. These three summer flocks were made up of ewes which commenced to lamb April 10 and which had practically finished lambing May 15. The lambs in the three flocks were of the same age and of the same breeding. On September 19, after being trailed from the summer range to the railroad for shipment, the average weight of 1,262 lambs in flock A, which had grazed on the shaded range, was 62½ pounds. The average weight of 1,301 lambs in flock B, summered on the partially shaded range, was 60¾ pounds; while in flock C the average weight of 1,198 lambs grazed on an open shadeless range was 56½ pounds. The average daily gain of flock A was .4096, of flock B .3996, and of flock C .3717 pounds. Between flock A and flock C there was a difference in the gain of the lambs of 5¾ pounds in favor of the shaded lambs.

In an average range flock of 1,500 lambs the above difference in the summer growth of the lambs of the two flocks would amount to 8,625 pounds. This difference in the gains made by the lambs in the three flocks from which the summer-growth weights were secured clearly emphasizes the importance that shade plays in the summer management of sheep. Consequently it is highly desirable whenever possible to graze the open ranges first, reserving the range forage where shade is available for the long warm days of summer.

THE EFFECT OF TRAILING ON THE GROWTH OF THE LAMB

The effect of trailing long distances in order to get to and from fresh feed is well illustrated by the following case: A camp-tender had failed to move the herder's camp for eleven days, and the range was badly overgrazed in the immediate vicinity of the camp, so that the ewes and lambs were forced to trail approximately 1½ to 2½ miles to get to fresh feed. During this period of long trailing to get fresh feed three lambs were weighed in order to determine just what gains they were making when being forced to trail so far each day. The three lambs weighed 49, 55¾, and 56½ pounds, respectively. Each morning for four days they were weighed, and it was found that their average increase was .25 of a pound per day. With their mothers and the other animals in the flock they were moved and put on fresh green feed and the long trails eliminated.

They commenced to gain flesh immediately. Four days after the change of feed the three lambs had made an average gain of .32 of a pound per day, an increase of .07 of a pound per day over what they were making when compelled to make the long daily trail. This material increase in daily growth was caused by the change in the character and abundance and nearness of the feed. The long daily trails to fresh feed and back had prevented the ewes from giving the necessary amount of milk for the continued rapid growth of the

lamb and had kept both ewes and lambs down in flesh; this was shown by the condition and appearance of their bodies. If this practice of maintaining a central camp from which and to which the ewes and lambs were forced to trail each day had been continued for a grazing season of 100 days, it would have caused the production of lambs weighing on an average 7 pounds less than lambs which had been allowed to bed down with their mothers wherever they were on the range at night. Seven pounds each in the average flock of 1,500 lambs means 10,500 pounds of flesh and wool. This item is certainly worth considering, more especially when it is multiplied by the hundreds of thousands of lambs produced annually on Nevada ranges.

THE EFFECT OF DIFFERENT TYPES OF RANGE FORAGE ON MILK PRODUCTION BY EWES

The daily milk yield of the ewe has a very marked influence on the growth of the lamb. When a lamb is first starting out in life it takes from its mother considerable fat, which is known on the range as "mother tallow." It makes its most rapid growth during the early period of its life, and the growth of the first month or six weeks is mainly controlled by the supply of milk produced by the ewe. After this period has passed the lamb gradually begins to forage for itself, so that it is not nearly so dependent upon its mother.

The amount of milk produced by the ewe varies with the different breeds, with individuals of the same breed, with the manner in which they are handled, and with the kind of range on which they graze. Ordinarily, sheep prefer succulent weeds and will make the greatest improvement on this type of forage. A grass range is used to the best advantage when it is grazed by cattle. In order to determine what effect different types of range forage would have on the production of milk, two ewes and lambs of Rambouillet breeding were selected for study. The lambs were kept away from the ewes except at stated intervals when they were allowed to suckle their mothers. The ewes were first grazed on a range where the feed was mainly grasses and which was becoming coarse and more or less dry. The average milk production of the ewes on this type of range was 1.6 pounds per day. Shortly they were moved to a range which supported succulent grasses and weeds, and the milk supply immediately advanced to 2.1 pounds per day, an increase of .5 of a pound of milk. The gains in the weights of the lambs were not considered, for it was necessary to keep the lambs in camp while their mothers were out on the range grazing, and this condition was so abnormal that they did not do well. However, it illustrates the importance of succulent grasses and weeds for the production of milk and the rapid and steady growth of the lamb.

Thus it is clearly apparent that the continued rapid growth of the lambs requires a range supporting an abundance of succulent forage. Camp-tenders and sheepherders should therefore utilize their range and select their grazing camps so that the early range will be used first, keeping the higher camps and the areas along the streams for use during the hot weather of July and August. Too often range which should be used later on in the season is grazed off early; and during the hottest period of the summer the sheep are forced to eat dry feed, oftentimes going without any shade. As a result, the milk supply of the ewe is materially diminished and the lambs do not

make the growth that would have been made if their mothers had been given the opportunity to shade up during the hot part of the day and had been allowed to feed upon the late-maturing succulent range forage at the proper time. The use of the range forage so that shade can be produced for the ewes and lambs during the hottest part of the grazing season, with green succulent feed near water, is not given the attention it should receive in the management of sheep on Nevada ranges.

A COMPARISON OF THE GAINS MADE BY LAMBS UNDER THE TWO SYSTEMS

In order to determine the effect of the two systems upon the growth of the lambs, twenty average individuals were chosen from each flock, and weighed at the beginning of the grazing season and again at the close. The comparative gains made by the various groups of lambs are given in the following tables:

The Gains Made by Lambs Under the System of One-Night Camps

Flock	Year	Actual days of grazing	Average weight at—		Gain per head	Average gain per day
			Beginning	Close		
No. 1	1916	78	42.2 lbs.	70.0 lbs.	27.7 lbs.	.380 lbs.
No. 2	1916	63	45.5 lbs.	69.1 lbs.	23.6 lbs.	.375 lbs.
No. 3	1916	62	43.8 lbs.	66.0 lbs.	22.2 lbs.	.359 lbs.
No. 4	1917	42	45.2 lbs.	61.5 lbs.	16.3 lbs.	.390 lbs.
No. 5	1917	49	47.4 lbs.	64.3 lbs.	16.9 lbs.	.345 lbs.
No. 6	1917	62	47.0 lbs.	68.7 lbs.	21.7 lbs.	.350 lbs.
Average	....	58.5	45.2 lbs.	66.6 lbs.	21.4 lbs.	.3665 lbs.

The Gains Made Under the System of Established Bed-Grounds

Flock	Year	Actual days of grazing	Average weight at—		Gain per head	Average gain per day
			Beginning	Close		
No. 1	1916	55	52.0 lbs.	67.0 lbs.	15.0 lbs.	.273 lbs.
No. 2	1916	67	33.6 lbs.	53.8 lbs.	20.2 lbs.	.302 lbs.
No. 3	1916	66	38.1 lbs.	60.4 lbs.	22.3 lbs.	.338 lbs.
No. 4	1917	62	36.2 lbs.	57.2 lbs.	21.0 lbs.	.340 lbs.
No. 5	1917	65	30.4 lbs.	51.7 lbs.	21.3 lbs.	.328 lbs.
No. 6	1917	68	35.1 lbs.	56.5 lbs.	21.4 lbs.	.315 lbs.
Average	....	63.8	37.5 lbs.	57.7 lbs.	20.2 lbs.	.316 lbs.

The tables show that under the system of one-night camps the lambs made an average daily gain of .3665 of a pound. Under the system of returning to an established bed-ground they gained daily .316 of a pound—a difference of .0505 pounds per head per day in favor of the lambs grazed under the bedding-out system. This may appear to be a very small difference; yet for a grazing season of 100 days it represents an increase of 5.05 pounds. For a flock of 1,500 lambs it means a net increase of 7,575 pounds.

On January 1, 1917, the statistics show that there were 1,340,000 sheep within the State of Nevada. Assuming that 20% of this number are yearlings, bucks, and immature animals, it leaves 1,072,000 mature breeding ewes. The 1,072,000 breeding ewes should, under ordinary range conditions, produce a crop of 80% docked lambs or

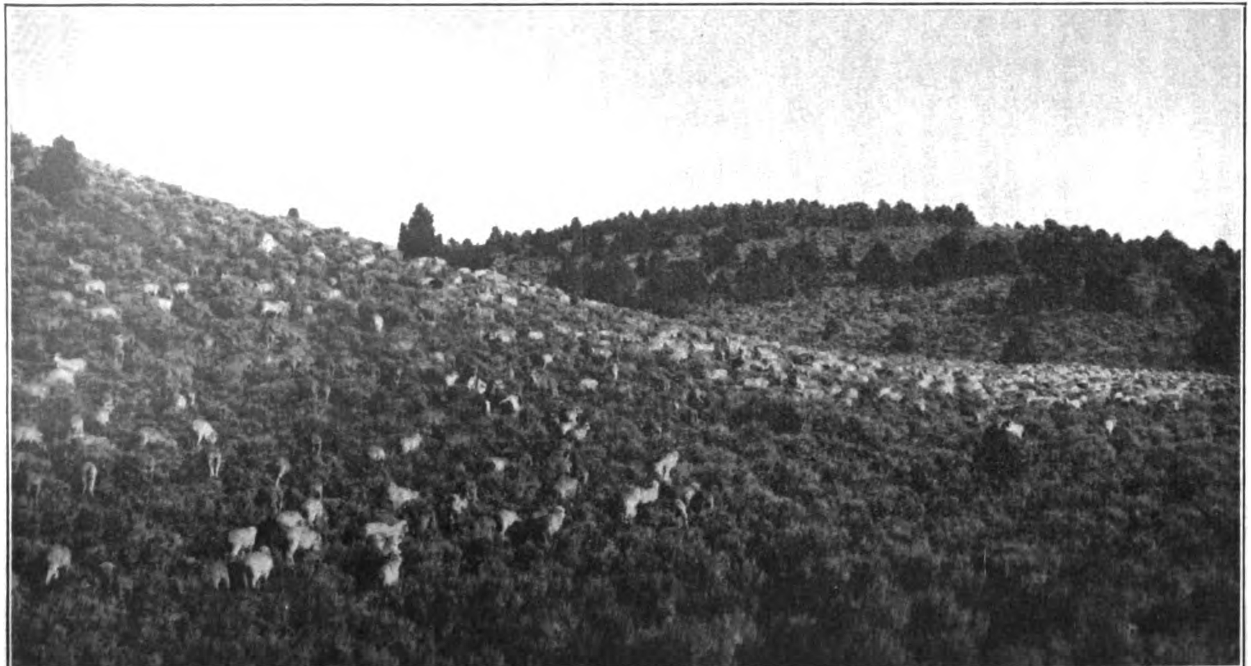


Figure 9. Tail-end herding taking place. Turn the leaders and do not try to make the slow-trailing sheep keep up with the fast-trailing leaders. Note massed formation at rear of band.

857,600 lambs to be fed on the summer grazing ranges. Let us assume that one-half of these lambs are now being run under the best methods of handling, so as to produce the maximum growth in the lamb during the average summer grazing period. Now, if by improved methods of handling, the weight of each lamb can be increased for the other one-half of all Nevada lambs by 5.05 pounds, as shown by the figures of the preceding tables, the total increased production for the State, over what it is now, would be 2,165,440 pounds of mutton for the same area of range. If the increased production per lamb amounted to only 2 pounds, still the total increase would be extremely important.

The increased money value at 14 cents per pound for a flock of 1,500 lambs would amount to 1,500 times 5.05 times .14, or $1,060.50. This would represent just that much more profit to the sheep owner and would go a long way towards paying the summer operating expenses of a band of ewes and lambs.

The foregoing increase in the weights of lambs when handled under the bedding-out system is primarily due to the following factors: (1) The ewes are on fresh feed every day with many different kinds of plants to select from, and, as a consequence, they give more and better milk than ewes fed every morning on range which has already been grazed or ewes which trail for three miles a day to get feed. (2) The loss of time and energy consumed in trailing from an established camp is entirely eliminated. (3) The ewes and lambs are in most instances allowed to graze at all times just as openly and quietly as possible, giving them the greatest possible range freedom in the selection of their feed with the least amount of dogging, trailing, and running taking place. (4) The ewes are allowed to choose range forage which will help to produce both wool and mutton.

THE USE MADE OF THE RANGE UNDER THE TWO SYSTEMS

In order to determine the degree of use made of the range when the sheep are returned to the same bed-ground in comparison with the system of being allowed to bed where night overtakes them, a series of small areas or quadrates six feet square were selected on two different ranges before the sheep began to graze them; and the total number of plants on each of the small areas was listed. At the close of the grazing season the plants were again recorded in order to determine the number removed or the degree of use of forage which had taken place for each range. The two areas selected for this test were open rolling country where it was possible for the sheep to feed over every portion of the range with ease. The forage growing on these ranges was made up almost wholly of grasses and weeds, a very uniform stand over all of the area grazed.

The quadrates on the range where the sheep were returned to a fixed bed-ground were laid out from a central camp so that a quadrate was found in the ¼-mile, ½-mile, ¾-mile, 1-mile, 1¼-mile, 1½-mile, 1¾-mile, and 2-mile zones, respectively. At the close of the season 97% of the plants had been removed from the ¼-mile zone, 95% in the ½-mile zone, 93% in the ¾-mile zone, 68% in the 1-mile zone, 48.4% in the 1¼-mile zone, 20.5% in the 1½-mile zone, 14.1% in the 1¾-mile zone, and in the 2-mile zone no appreciable utilization had taken place. Thus, the range was heavily overgrazed in the immediate vicinity of the bed-ground, while range two miles away was unused.

On the range where the sheep had been allowed to select their own bed-ground each night, an average of 84.4% of the plants had been removed from each of the 32 quadrates established, and thus a very uniform utilization of the entire area had taken place, only 15.6% of the forage being left ungrazed. On this range no area was completely grazed at one time, but was left to be regrazed at a later date. As a result, no injury was done to any part of this range, while in the case of the range where the sheep were returned to a central camp the range close to the bed-ground was badly abused and overgrazed. Of course, the percentages given will vary with each different range and even with the same range, depending on the herder and the length of time the sheep are on the range, the climatic conditions affecting the growth of the forage plants, and the size of the flock. However, they do give comparative figures which illustrates admirably the fact that the range forage may be efficiently used or badly abused simply by the manner in which the sheep are handled.

There can be no question that the carrying capacity of the range, where equal and uniform grazing takes place, is materially greater than where certain portions are injured by overgrazing and other portions scarcely two miles from the central camp are not used at all.

Where the sheep graze on a fresh range every day, the plants have a chance to go to seed. Ordinarily this would not take place if all the forage had been removed at one time as it is around a fixed bed-ground. Thus, not only is there a material saving in forage, due to the elimination of waste through trailing and overgrazing, but the carrying capacity of a grazed range may even increase each year because the plants already found on the range are allowed to go to seed.

THE CARRYING CAPACITY OF THE RANGE UNDER THE TWO SYSTEMS

Not only does the carrying capacity of the range vary according to the different kinds of plants making up the forage grazing types and the density of their growth, but it varies also according to the manner in which the sheep are handled. In order to determine the difference in the carrying capacity of the range when the sheep were handled under the system of established bed-grounds and when they were allowed to bed down wherever night overtook them, six sheep ranges were selected for comparative study during the summers of 1916 and 1917.

The following tables give the carrying capacity of the range for each of the areas under observation:

Sheep Handled Under the Bedding-Out System

Flock	Year	Ewes	Lambs*	Total sheep	Actual days of grazing	Total acreage grazed	Acreage utilized per day per sheep	Acreage utilized per 100 days per sheep
No. 1	1916	1,656	1,492	2,402	73	3,413	.0195	1.95
No. 2	1916	1,881	1,515	2,638	63	2,938	.0177	1.77
No. 3	1916	1,485	1,273	2,121	62	2,669	.0203	2.03
No. 4	1917	1,573	988	2,067	60	2,410	.0194	1.94
No. 5	1917	1,883	1,007	2,386	49	1,776	.0152	1.52
No. 6	1917	2,011	1,172	2,597	62	2,775	.0172	1.72
Average....							.0182	1.82

*Two lambs considered equivalent to one mature sheep.

Sheep Handled Under the Established Bed-Ground System

Flock	Year	Ewes	Lambs*	Total sheep	Actual days of grazing	Total acreage grazed	Acreage utilized per day per sheep	Acreage utilized per 100 days per sheep
No. 1	1916	1,439	1,421	2,149	55	2,697	.0227	2.27
No. 2	1916	1,604	1,583	2,395	67	3,915	.0244	2.44
No. 3	1916	1,685	1,602	2,486	66	3,413	.0208	2.08
No. 4	1917	1,825	1,100	2,375	62	3,050	.0207	2.07
No. 5	1917	1,930	1,080	2,470	65	4,050	.0252	2.52
No. 6	1917	2,012	820	2,422	88	5,578	.0261	2.61
Average							.0233	2.33

*Two lambs considered equivalent to one mature ewe.

The tables show that where the ewes and lambs were handled under the bedding-out system they utilized 1.82 acres per sheep per 100 days grazing season as compared to 2.33 acres per sheep per 100 days when they were returned to an established camp each night. Thus, when a new camp was made every night, it took 21.9% less range to support a sheep than it did when the camp was kept for many nights in the same place.

This increase in carrying capacity may be accounted for by the following facts: (1) The sheep are not forced to return each night over range already eaten off, but are allowed to pass over the ground only once and thus the loss of forage through trampling is greatly reduced. (2) A given piece of range is not fully eaten off at any one time, but is regrazed at a later date, thus permitting the plants to put forth fresh leaves after once being cropped, instead of being completely eaten to the ground, which materially impairs the vitality of the plants for any future growth during that season. (3) When sheep are allowed to graze openly and quietly they are spread out in open formation and only a few hoofs, at most, will strike any given plant, which reduces the injury to the range from hoofing. (4) Less waste of forage takes place, for sheep trail less when choice feed is available. (5) There is less packing of the soil; packing causes it to dry out more rapidly with a consequent damage to the growth of the range plants. (6) There is a more even use of the area grazed, for there is no overgrazing and extremely close grazing in the immediate vicinity of an established bed-ground with incomplete use of the more distant areas.

If a certain area of sheep range has a carrying capacity of 5,000 head under the established bed-ground system, then, with a saving of 22% of vegetation which actually takes place where the bedding-out system is used, that same range under the latter system would have a carrying capacity not of 5,000 head but of 6,100. If such a conservation of forage could be affected over all of our public-domain range, it would mean a tremendous increase in the carrying capacity of our summer grazing ranges, or, in other words, a much larger number of stock could be ranged than at the present time. Even if no more animals were run than at the present time, our overgrazed and worn-out public ranges would have a chance to recover by natural seeding.

THE UNIVERSITY OF NEVADA

AGRICULTURAL EXPERIMENT STATION

Bulletin No. 104 RENO, NEVADA Sept. 1, 1922

To diminish suffering and loss among domestic animals

THE SPRING RABBIT-BRUSH

(*Tetradymia glabrata*)

A Range Plant Poisonous to Sheep

By

C. E. FLEMING
M. R. MILLER and L. R. VAWTER

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

Hon. B. F. Curler (1923)	Elko
Hon. Walter E. Pratt (1925)	Reno
Hon. Mrs. W. H. Hood (1927)	Reno
Hon. Miles E. North (1929)	Reno
Hon. G. F. Talbot (1931)	Reno

OFFICERS

Walter E. Clark, Ph.D.	President of University
Carolyn Beckwith	Secretary
Charles H. Gorman	Comptroller

STAFF

Samuel B. Doten, M.A., Director	Entomologist
F. L. Bixby, C.E. (In cooperation with Bureau of Public Roads, U.S.D.A.)	Irrigation
Geo. Hardman, M.S.	Assistant in Irrigation
Charles E. Fleming, B.S.A.	Range Management
Edward Records, V.M.D.	Veterinarian
Lyman R. Vawter, D.V.M.	Pathologist
Mary McGee	Secretary to Veterinary Department
M. R. Miller, B.S.	Chemist
Martha Ryan	Librarian and Secretary to Director
Marc LeDuc	Fellow in Chemistry

SUMMARY

1. The spring rabbit-brush is a common poisonous shrub of the desert foothills in Nevada and several other Western States.
2. In late summer, autumn and winter, it is a leafless gray brush; stiff and dense but not spiny, from one to four feet high. In the spring it puts out a tender growth of light-gray stems and short, slender fleshy green leaves with clusters of oblong greenish-white buds which bloom into small fuzzy yellow flowers in May.
3. Sheep do not like the spring rabbit-brush and will not eat it unless they are hungry; then they will eat the tender new growth if other feed is scarce.
4. A mature range sheep can eat moderate quantities of this plant, up to nearly two pounds, without apparent harm; but the poison is only slowly thrown off and if even a little of the plant is eaten every day it will accumulate in the body, finally causing severe sickness or death.
5. The poisoned sheep stops eating and begins to drool a little. It becomes restless and walks about, a few steps forward and a few back; and may stand for a time holding its head against a fence or other convenient object. The heart beats rapidly, but there is very little fever. The muscles twitch on the neck and shoulders; the animal walks unsteadily, staggers, and goes down. It may lie for hours, growing more dull and indifferent to its surroundings. The breathing is difficult and irregular; the unconscious animal finally dies without spasms or struggle, so quietly that a close watch must be kept if the observer is to record the time of death.
6. When a sheep has been fatally poisoned by small quantities of the plant eaten daily for ten days or more, death follows the first symptoms of illness within ten to eighteen hours. But when a fatal dose has been taken in a single feeding, the illness is more prolonged; and death does not occur until the animal has been ill for from twenty-four to thirty-six hours; it may even linger for three days.
7. After death the body gives evidence of severe inflammation of the stomach and intestines, with hemorrhages under the skin of the face and neck and under portions of the membrane covering the

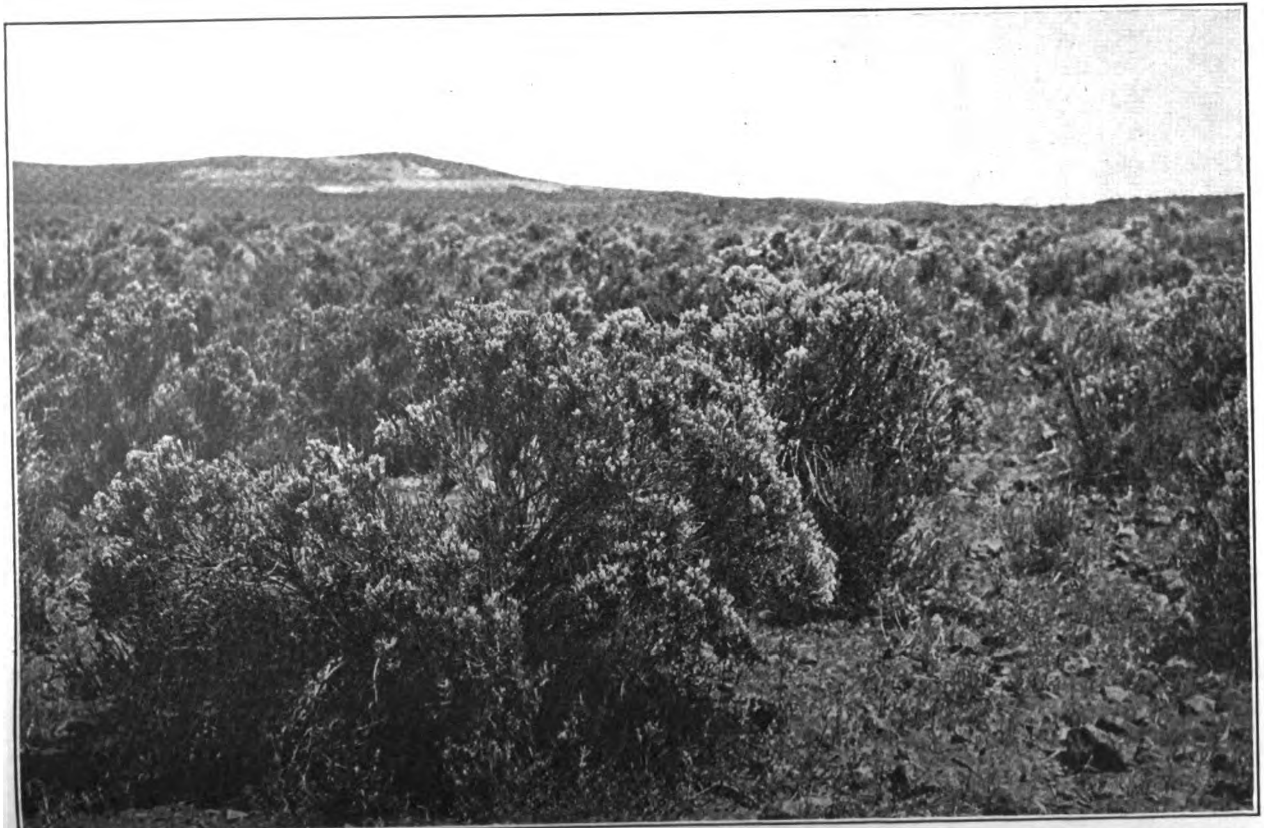


FIGURE 1. A Typical Rabbit-Brush Range, showing Full Development of the Young Stems and Buds. On this range [illegible] were lost from grazing this plant at the stage of growth here shown.

heart, together with some inflammation of the kidneys, congestion of the lungs and degenerative changes in the heart and liver. These conditions, however, are not characteristic of poisoning by the spring rabbit-brush alone; but when they occur and a strong odor of the plant is noticed on opening up the body of the sheep, there is good reason for thinking that this plant is the cause of the trouble.

8. Experiments have shown that the essential oil which gives the brush its odor does not contain the poisonous principle. There is also an unusual quantity of potash salts in the buds and green growth; but careful tests have shown that poisoning is not due to the potash. The active poisonous principle of the plant has not been discovered.
9. There is no known remedy for poisoning by the spring rabbit-brush. Methods of treatment tested have proven unsuccessful.
10. Poisoning by this plant may occur around dipping plants, shearing corrals, or shipping points or wherever there are hungry sheep on ranges where the spring rabbit-brush is plentiful and good feed is scarce, or when late snows on spring ranges cover the grasses and tender plants, leaving the brush exposed.
11. Poisoning may be prevented by keeping hungry sheep off ranges where there is little or nothing but the spring rabbit-brush.

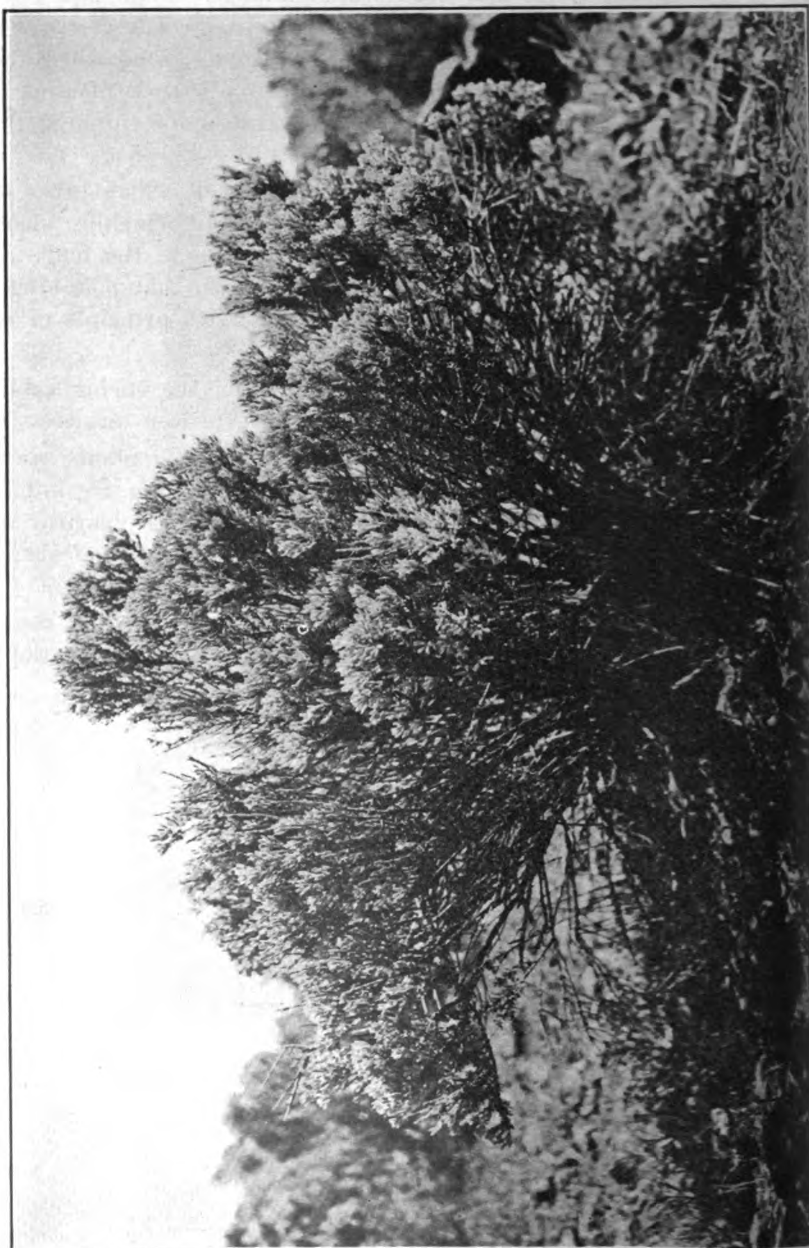


FIGURE 2. A Close-up View of Spring Rabbit Brush showing the Plant When in Its Most Dangerous Stage of

SECTION I

Studies of the Poisonous Effects of Spring Rabbit-Brush

(*Tetradymia glabrata*)

In recent years many deaths from poisonous plants have occurred in Nevada among sheep grazing in late winter and early spring on the open ranges; yet, after careful examination of the country, it was clear that the trouble was not due to any plant commonly recognized as poisonous.

This bulletin deals with a plant which a few years ago was not suspected of being responsible for livestock losses.

Common Names.

On the range this plant is commonly called "rabbit-brush." However, this same common name is used by stockmen for several different brushy shrubs of the desert foothills; and so, like many other common names of plants, it does not mean much unless one knows just which "rabbit-brush" is under discussion. The one described herein is green only during the spring and early summer; for which reason a good common name for it would be "spring rabbit-brush." It is known to botanists as *Tetradymia.glabrata*.

Description of the Plant.

Like sagebrush the spring rabbit-brush is a low, dense, rigid shrub growing from one to three feet high. The older branches are gray; the stems and branches of newer growth are greenish-white; the little green leaves are slender, not notched, fleshy and smooth. On the older branches the leaves are a little more than one-eighth of an inch long; on the young growing shoots they reach a length of half an inch. The numerous small yellow flowers are from one-eighth to one-fourth of an inch across, blooming in clusters in May on the ends of the new twigs.

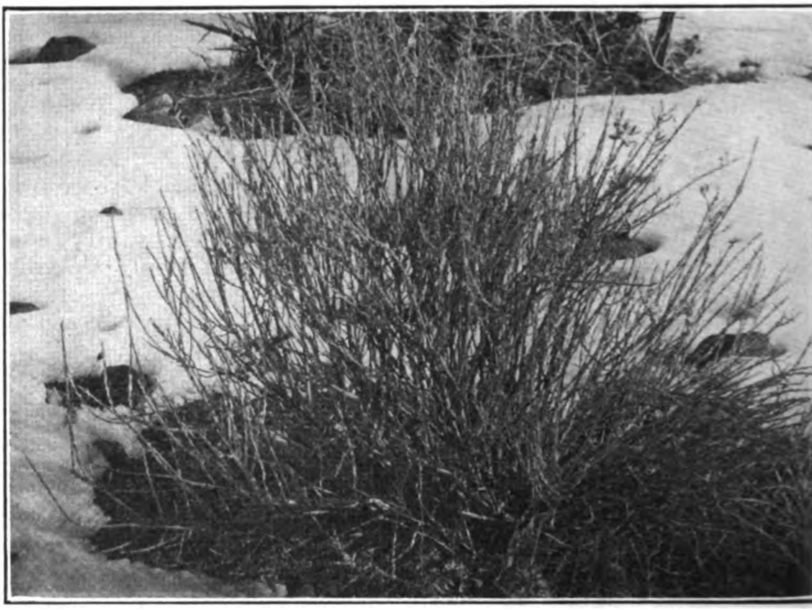
Parts of the Western Range Country Where This Plant Grows.

The spring rabbit-brush is found in Oregon, Idaho, Utah, California, and Nevada. In Nevada it grows on the treeless foothills and flats with the sagebrush, the golden brush or false goldenrod bush, the hop sage, the saltbush and a scattering growth of weeds and grass. On some of the slopes and flats there is nothing but this rabbit-brush; on others there is a mixture of many different kinds of bushes.

The Season of Growth.

The spring rabbit-brush makes all of its growth in the spring and early summer and is dormant and leafless during the remainder of the year. At about the time when the snow is leaving the ranges the rabbit-brush shows signs of life and the buds begin to swell. Soon afterward the new green buds and leaves come out; and usually by the middle of June it has completed its growth for the year. The plant then dries up, the leaves fall, and it looks like a barren woody shrub. Figure 3 shows the spring rabbit-brush in its dormant state.

FIGURE 3



a. **Spring Rabbit-Brush on Range Partly Covered With Snow in Early Spring When the Buds Have Formed. Under these conditions such a range is highly dangerous.**

b. **Hungry Sheep Will Eat the Spring Rabbit-Brush When Snow Covers All the Grass and Tender Plants of the Spring Range.**

The Time of Year When the Plant Is Dangerous.

There is only a short period in the spring and early summer when this brush is at all dangerous to live stock. As has been stated, it develops its leaves and buds during the first warm days of early spring and soon afterwards completes its growth, sheds its leaves, and becomes bare and leafless and apparently dead. It is only during the period of buds and leaves and flowers that it is dangerous.

The Part of the Plant Which Is Poisonous.

During its growing period the plant produces along its main branches leaves which are so small that they are seldom or never touched by the sheep. The young leafy stems and flower-buds are easily grazed and are the parts of the plant which cause poisoning.

The Kinds of Live Stock Poisoned by the Spring Rabbit-Brush.

So far, the recorded losses have been confined to sheep. There is some probability that goats might be poisoned, but there are few if any flocks of goats on Nevada ranges; and what effect the plant might have upon them is not known. It is difficult for cattle to graze this shrub extensively; and it is very distasteful to them. All our feeding tests with cattle produced no symptoms of poisoning. There is no risk of poisoning in horses because of their habits on the range and the way in which they are handled.

Losses Due to Spring Rabbit-Brush.

The largest recorded loss was in a flock of ewes and lambs where approximately 1,000 ewes died as a direct result of eating this plant, leaving their young lambs as orphans. Other losses reported range from 500 head down, in flocks grazing on spring rabbit-brush range or being trailed over country where this brush is abundant.

Feeding Tests to Discover the Poisonous Properties of the Plant.

The feeding tests were made for the following reasons: (1) to find out what part of the plant is poisonous; (2) to learn how much it takes to make a sheep sick or to kill it; (3) to discover the effect upon the sheep of small quantities fed daily; (4) to record the symptoms of poisoning; (5) to discover remedies, if possible, and (6) to record the post-mortem conditions.

FIGURE 4. Spring Rabbit-Brush Showing the Large Green Buds, the Part of the Plant Mainly Responsible for All Losses From This Plant.

FIGURE 5. A Portion of a Spring Rabbit-Brush Plant Showing the Long Tender Stems and Large Juicy Buds Which Are Poisonous to Sheep.

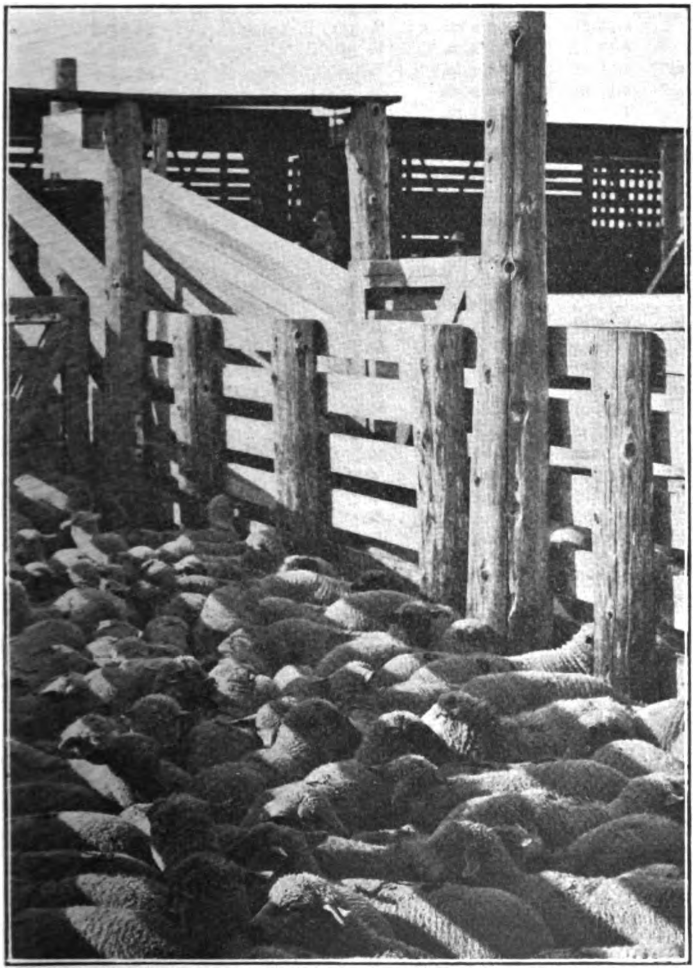


FIGURE 6. When Hungry Sheep Are Unloaded from Stock Cars and Allowed to Graze Upon a Spring Rabbit-Brush Range There Is Danger of Fatal Poisoning.

TABLE I—SHEEP

Daily Quarter-Pound Feedings of the Green Growth of Spring Rabbit-Brush

Animal No.	Wt. lbs.	Date	Time	Amt. fed lbs.	Time symptoms appeared	Time of death or recovery	Final result
25	88	4-15-21	9:00 a.m.	¼			negative
26	72	4-15-21	9:30 a.m.	¼			
		4-16-21	9:45 a.m.	¼			negative
27	84	4-15-21	10:00 a.m.	¼			
		4-16-21	10:00 a.m.	¼			
		4-17-21	10:15 a.m.	¼			negative
28	92	4-20-21	1:00 p.m.	¼			
		4-21-21	2:00 p.m.	¼			
		4-22-21	1:30 p.m.	¼			
		4-23-21	1:15 p.m.	¼			negative
29	83	4-20-21	2:00 p.m.	¼			
		4-21-21	3:00 p.m.	¼			
		4-22-21	2:20 p.m.	¼			
		4-23-21	2:15 p.m.	¼			
		4-24-21	3:30 p.m.	¼			negative
30	88	4-21-21	10:00 a.m.	¼			
		4-22-21	11:45 a.m.	¼			
		4-23-21	9:10 a.m.	¼			
		4-24-21	3:30 p.m.	¼			
		4-25-21	11:20 a.m.	¼			
		4-26-21	1:00 p.m.	¼			negative
31	96	4-21-21	9:10 a.m.	¼			
		4-22-21	10:30 a.m.	¼			
		4-23-21	9:45 a.m.	¼			
		4-24-21	4:30 p.m.	¼			
		4-25-21	1:00 p.m.	¼			
		4-26-21	2:30 p.m.	¼			
		4-27-21	3:25 p.m.	¼			negative
32	94	4-23-21	3:00 p.m.	¼			
		4-24-21	1:40 p.m.	¼			
		4-25-21	11:20 a.m.	¼			
		4-26-21	10:45 a.m.	¼			
		4-27-21	9:00 a.m.	¼			
		4-28-21	1:00 p.m.	¼			
		4-29-21	2:10 p.m.	¼			
		4-30-21	3:35 p.m.	¼			negative
33		4-29-21	9:20 a.m.	¼			
		4-30-21	2:10 p.m.	¼			
		5- 1-21	2:45 p.m.	¼			
		5- 2-21	3:25 p.m.	¼			
		5- 3-21	4:00 p.m.	¼			
		5- 4-21	11:30 a.m.	¼			
		5- 5-21	1:20 p.m.	¼			
		5- 6-21	10:10 a.m.	¼			
		5- 7-21	9:35 a.m.	¼			negative
35	91	5- 5-21	4:25 p.m.	¼			
		5- 6-21	3:25 p.m.	¼			
		5- 7-21	3:40 p.m.	¼			
		5- 8-21	2:25 p.m.	¼			
		5- 9-21	1:10 p.m.	¼			
		5-10-21	2:45 p.m.	¼			
		5-11-21	11:00 a.m.	¼			
		5-12-21	9:30 a.m.	¼			
		5-13-21	10:40 a.m.	¼			
		5-14-21	10:15 a.m.	¼			negative
36	90	5- 8-21	8:20 a.m.	¼			
		5- 9-21	9:45 a.m.	¼			
		5-10-21	11:05 a.m.	¼			
		5-11-21	2:30 p.m.	¼			
		5-12-21	3:00 p.m.	¼			
		5-13-21	1:40 p.m.	¼			
		5-14-21	10:30 a.m.	¼			
		5-15-21	9:35 a.m.	¼			

TABLE I—*Continued*

Animal No.	*Wt. lbs.*	*Date*	*Time*	*Amt. fed lbs.*	*Time symptoms appeared*	*Time of death or recovery*	*Final result*
		5-16-21	11:10 a.m.	¼			
		5-17-21	4:05 p m.	¼			
		5-18-21	3:15 p.m.	¼			
		5-19-21	2:35 p.m.	¼	2.00 p.m. 5-21	9:00 a.m. 5-23	recovery
700	75	5-25-22	2:45 p.m.	¼			
		5-26-22	10:00 a.m.	¼			
		5-27-22	2:45 p.m.	¼			
		5-28-22	8:30 a.m.	¼			
		5-29-22	11:45 a.m.	¼			
		5-30-22	8:30 a.m.	¼			
		5-31-22	9:30 a.m.	¼			
		6- 1-22	10:15 a.m.	¼			
		6- 2-22	10:00 a.m.	¼			
		6- 3-22	8:30 a.m.	¼			
		6- 4-22	4:00 p.m.	¼			
		6- 5-22	11:00 a.m.	¼			
		6- 6-22	8:30 a.m.	¼	6-11	6-13	recovery
374	94	4-30-21	11:00 a.m.	¼			
		5- 1-21	6:10 a m.	¼			
		5- 2-21	1:30 p.m.	¼			
		5- 3-21	1:45 p.m.	¼			
		5- 4-21	3:00 p.m.	¼			
		5- 5-21	3:00 p.m.	¼			
		5- 6-21	11:45 a.m.	¼			
		5- 7-21	4:45 p.m.	¼			
		5- 8-21	8:30 a.m.	¼			
		5- 9-21	4:15 p.m.	¼			
		5-10-21	11:45 a.m.	¼			
		5-11-21	11:30 a.m.	¼			
		5-12-21	11:00 a.m.	¼	7:30 a.m 5-13	8:00 a.m. 5-14	death
363	84	4-30-21	10:30 a.m.	¼			
		5- 1-21	5:45 p.m.	¼			
		5- 2-21	2:00 p.m.	¼			
		5- 3-21	2:00 p.m.	¼			
		5- 4-21	2:30 p.m.	¼			
		5- 5-21	3:00 p.m.	¼			
		5- 6-21	1:30 p.m.	¼			
		5- 7-21	4:30 p.m.	¼			
		5- 8-21	9:00 a.m.	¼			
		5- 9-21	4:00 p.m.	¼			
		5-10-21	10:30 a.m.	¼			
		5-11-21	2:30 p.m.	¼			
		5-12-21	11:45 a.m.	¼	8:00 a.m. 5-13	5:15 p.m. 5-13	death
391	90	4-30-21	10:30 a.m.	¼			
		5- 1-21	6:30 a.m.	¼			
		5- 2-21	1:30 p.m.	¼			
		5- 3-21	1:30 p.m.	¼			
		5- 4-21	3:15 p.m.	¼			
		5- 5-21	3:15 p.m.	¼			
		5- 6-21	11:30 a m.	¼			
		5- 7-21	3:45 p.m.	¼			
		5- 8-21	8:00 a.m.	¼			
		5- 9-21	4:30 p.m.	¼			
		5-10-21	10:30 a.m.	¼			
		5-11-21	2:30 p.m.	¼			
		5-12-21	11:00 a.m.	¼	2:30 p.m. 5-13	8:00 a.m. 5-14	death

The results of the daily feeding tests recorded in Table I show: (1) that a single feeding of a quarter-pound of the spring rabbit-brush has no ill effect upon a sheep; (2) that a quarter-pound of it may be fed daily to a mature range sheep for periods of from two to ten days without causing any symptoms of poisoning; (3) that a quarter-pound fed daily for eleven successive days will make a sheep sick; (4) that the

same quantity fed daily for twelve or thirteen days in succession will make a sheep sick and may kill it.

These tests show that the poison of rabbit-brush is not thrown off immediately by the sheep, but slowly accumulates; in this way small quantities eaten daily may finally prove fatal. On a spring rabbit-brush range where sheep eat a little of the plant daily for some time, many of the animals will be apt to go off their feed and become sick, and some of them may die.

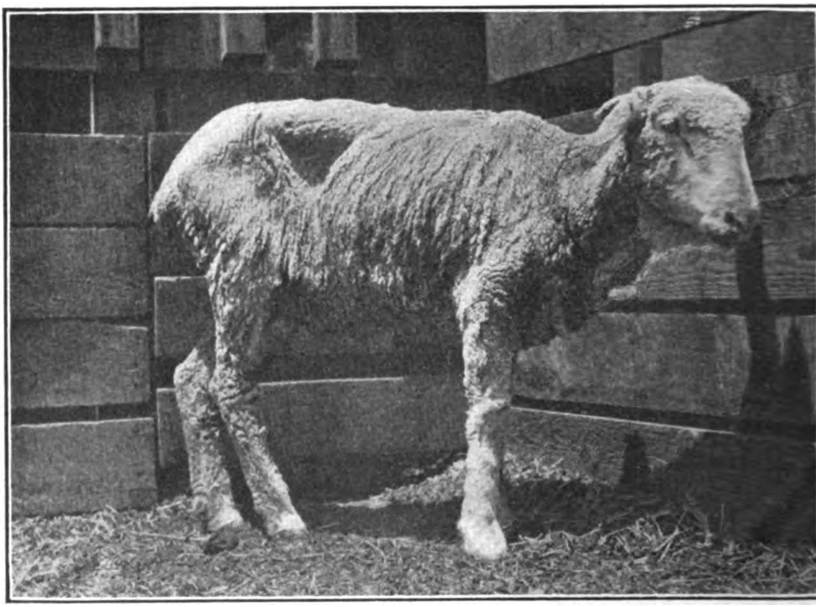


FIGURE 7. A Sheep Poisoned by Spring Rabbit-Brush Showing First Symptoms.

TABLE II—SHEEP

Daily Half-Pound Feedings of the Green Growth of Spring Rabbit-Brush

Animal No.	*Wt. lbs.*	*Date*	*Time*	*Amt. fed lbs.*	*Time symptoms appeared*	*Time of death or recovery*	*Final result*
16	71	5- 7-18	11:30 a.m.	½			negative
140	92	4- 5-21	9:10 a.m.	½			negative
141	99	4- 5-21	9:30 a.m.	½			negative
142	88	4- 5-21	10:30 a.m.	½			negative
157	96	4-26-21	10:30 a.m.	½			
		4-27-21	11:40 a.m.	½			negative
158	96	4-26-21	10:40 a.m.	½			
		4-27-21	11:00 a.m.	½			negative
159	98	4-26-21	9:00 a.m.	½			
		4-27-21	10:15 a.m.	½			negative
161	98	4-29-21		½			
		4-30-21		½			
		5- 1-21		½			negative
162	94	4-29-21	9:30 a.m.	½			
		4-30-21	10:30 a.m.	½			
		5- 1-21	9:50 a.m.	½			negative
163	90	4-29-21	1:20 p.m.	½			
		4-30-21	1:40 p.m.	½			
		5- 1-21	11:30 a.m.	½			negative

TABLE II—*Continued*

Animal No.	Wt. lbs.	Date	Time	Amt. fed lbs.	Time symptoms appeared	Time of death or recovery	Final result
383	95	4-30-21	3:30 p.m.	½			
		5- 1-21	6:45 a.m.	½			
		5- 2-21	2:15 p.m.	½			
		5- 3-21	11:50 a.m.	½			
		5- 4-21	2:30 p.m.	½	8:00 a.m. 5-6	5-8	recovery
692	110	5-25-22	2:30 p.m.	½			
		5-26-22	10:30 a.m.	½			
		5-27-22	2:45 p.m.	½			
		5-28-22	8:45 a.m.	½			
		5-29-22	11:35 a.m.	½	8:00 a.m. 5-29	6-8	recovery
26	70	6-28-18	1:30 p.m.	½			
		6-27-18	3:30 p.m.	½			
		6-29-18	3:30 p.m.	½			
		6-30-18	1:50 p.m.	½			
		7- 1-18	8:30 a.m.	½	7-3	7-5	recovery
325	92	4-30-21	11:00 a.m.	½			
		5- 1-21	6:15 a.m.	½			
		5- 2-21	2:15 p.m.	½			
		5- 3-21	11:45 a.m.	½			
		5- 4-21	3:00 p.m.	½	2:30 p.m. 5-5	5-8	recovery
160	91	4-30-21	2:40 p.m.	½			
		5- 1-21	3:00 p.m.	½			
		5- 2-21	9:10 a.m.	½			
		5- 3-21	11:00 a.m.	½			
		5- 4-21	1:30 a m.	½	6:10 p.m. 5-4	8:00 a.m. 5-5	death
379	70	4-20-21	2:40 p.m.	½			
		5- 7-21	6:15 a.m.	½			
		5- 2-21	2:05 p.m.	½			
		5- 3-21	1:45 p.m.	½			
		5- 4-21	2:30 p.m.	½	7:30 p.m. 5-4	10:30 a.m. 5-5	death

The facts given in Table II show that a single feeding of a half-pound of spring rabbit-brush has no effect upon a mature range sheep; that daily feedings of a half-pound for two, three, or four days do not seriously disturb the health of the animal, but if feeding is continued for five days the sheep will be made very sick and may not recover.

When one-quarter pound was fed daily it took a total amount of about 3¼ pounds to make a sheep sick or to kill it; with half-pound feedings it took a total of 2½ pounds. The tests show that a sheep gets rid of this poison very slowly; for, while it took over twice as long to cause sickness or death with the quarter-pound as with the half-pound feedings, still it took only a total of three-quarters of a pound more with quarter-pound feedings to cause sickness than it did with the half-pound feedings.

TABLE III—SHEEP

Daily Three-Quarter-Pound Feedings of Green Growth of Spring Rabbit-Brush

Animal No.	Wt. lbs.	Date	Time	Amt. fed lbs.	Time symptoms appeared	Time of death or recovery	Final result
342	90	5-17-21	4:00 p.m.	¾			
		5-18-21	4:00 p.m.	¾			
		5-19-21	3:20 p.m.	¾	3:45 p.m. 5:20	5-25	recovery
694	92	5-25-22	2:45 p.m.	¾			
		5-26-22	10:00 a.m.	¾			
		5-27-22	3:00 p.m.	¾			
		5-28-22	8:15 a.m.	¾	8:00 a.m. 5-29	6- 8	recovery
350	75	5-17-21	4:30 p.m.	¾			
		5-18-21	11:45 a.m.	¾			
		5-19-21	3:45 p.m.	¾			
		5-20-21	4:00 p.m.	¾	11:00 a.m. 5-20	4:30 p.m. 5-22	death

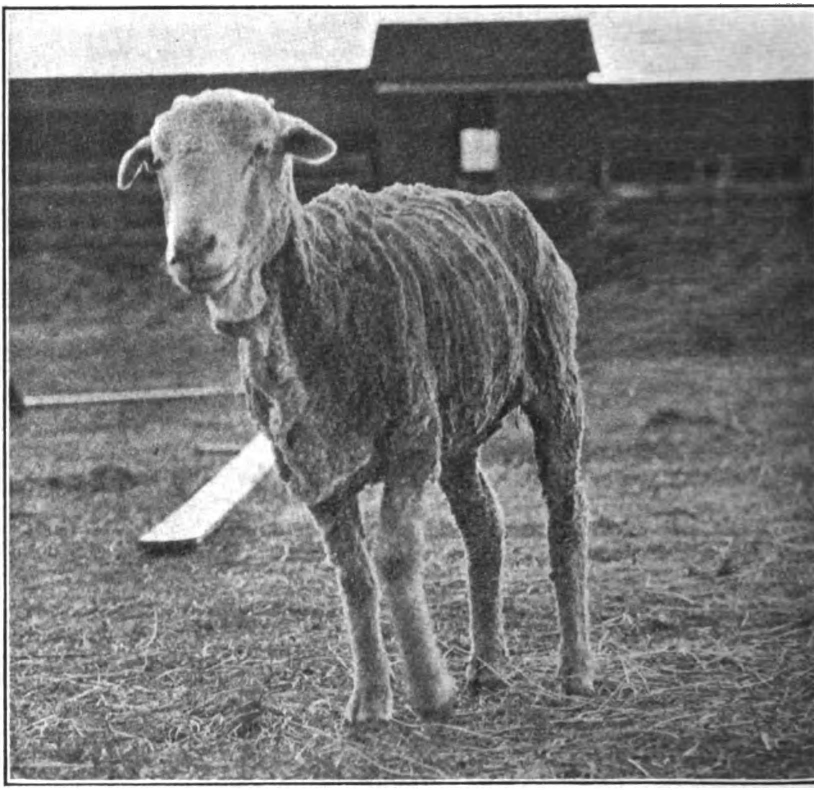


FIGURE 8. **A Sheep Fatally Poisoned by Spring Rabbit-Brush. The picture shows an animal which is just able to walk.**

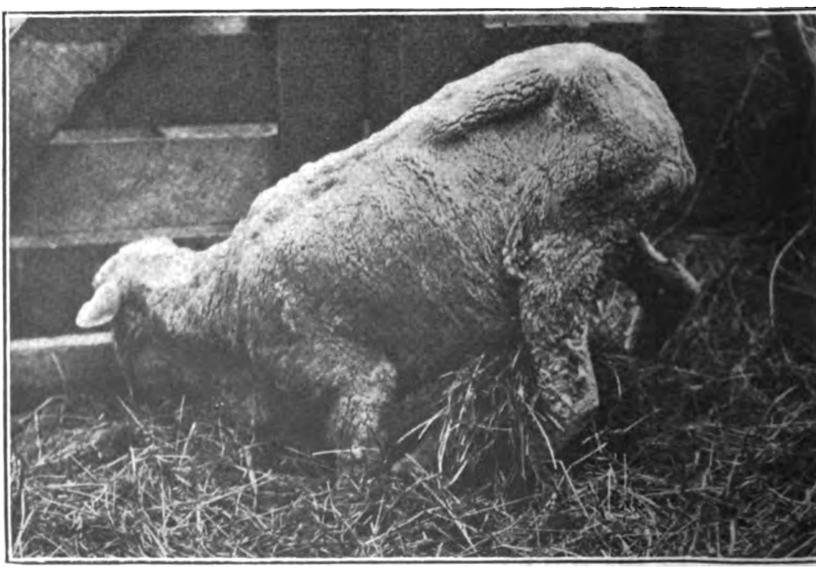


FIGURE 9. **A Sheep Poisoned by Spring Rabbit-Brush and Unable to Keep Upon Its Feet.**

TABLE III—*Continued*

Animal No.	*Wt. lbs.*	*Date*	*Time*	*Amt. fed lbs.*	*Time symptoms appeared*	*Time of death or recovery*	*Final result*
302	100	5-17-21	3:45 p.m.	¾			
		5-18-21	2:30 p.m.	¾			
		5-19-21	2:45 p.m.	¾			
		5-20-21	3:30 p.m.	¾	3:45 p.m. 5-20	8:00 a.m. 5-22	death
82	81	5-17-21	3:30 p.m.	¾			
		5-18-21	1:00 p.m.	¾			
		5-19-21	4:15 p.m.	¾			
		5-20-21	4:30 p.m.	¾	8:00 p.m. 5-20	9:00 p.m. 5-22	death
299	97	5-17-21	3:00 p.m.	¾			
		5-18-21	2:00 p.m.	¾			
		5-19-21	1:30 p.m.	¾			
		5-20-21	1:45 p.m.	¾	10:00 a.m. 5-20	9:45 a.m. 5-22	death

Table III shows that three-quarters of a pound of the green parts of the spring rabbit-brush fed daily for three days in succession will probably make a sheep sick; while if the same quantity is fed for four days death is apt to follow.

TABLE IV—SHEEP

Daily Feedings of One Pound of the Green Growth of Spring Rabbit-Brush

Animal No.	*Wt. lbs.*	*Date*	*Time*	*Amt. fed lbs.*	*Time symptoms appeared*	*Time of death or recovery*	*Final result*
22	84	5- 7-18	11:48 a.m.	1			negative
695	103	6- 1-22	2:00 p.m.	1			
		6- 2-22	10:15 a.m.	1	6- 4	6- 7	recovery
8	75	6- 8-18	3:30 p.m.	1			
		6- 9-18	3:10 p.m.	1			
		6-10-18	4:40 p.m.	1	8:00 p.m. 6-10	8:00 a.m. 6-13	death
60	96	5-26-22	4:00 p.m.	1			
		5-27-22	3:15 p.m.	1			
		5-28-22	8:00 a.m.	1	2:30 p.m. 5-28	8:00 a.m. 5-29	death
378	84	5-23-21	4:00 p.m.	1			
		5-24-21	4:00 p.m.	1			
		5-25-21	1:30 p.m.	1	5:20 p.m. 5-25	8:00 a.m. 5-26	death
696	94	5-26-22	4:00 p.m.	1			
		5-27-22	3:15 p.m.	1			
		5-28-22	8:00 a.m.	1			
		5-29-22	8:30 a.m.	1	8:00 a.m. 5-29	9:45 a.m. 6- 2	death
27	70	6-18-18	3:45 p.m.	1			
		6-19-18	3:20 p.m.	1			
		6-20-18	4:30 p.m.	1			
		6-21-18	3:10 p.m.	1	6-24	6-25	recovery
68	85	3-26-20	4:00 p.m.	1			
		3-27-20	9:30 a.m.	1			
		3-28-20	9:00 a.m.	1			
		3-29-20	10:00 a.m.	1	11:20 a.m. 3-20	8:00 a.m. 4- 1	recovery
101	100	4-10-21	10:25 a.m.	1			
		4-11-21	2:30 p.m.	1			
		4-12-21	2:30 p.m.	1			
		4-13-21	3:00 p.m.	1			
		4-14-21	2:30 p.m.	1	4-15	9:00 a.m. 4-16	death
698	130	5-25-22	2:30 p.m.	1			
		5-26-22	9:40 a.m.	1			
		5-27-22	3:00 p.m.	1			
		5-28-22	7:45 a.m.	1			
		5-29-22	4:30 p.m.	1	2:30 p.m. 5-30	6- 7	recovery

The figures given in Table IV show that a single feeding of one pound or of a pound a day for two days in succession will have little effect upon a mature range sheep; but feedings of a pound per day for three successive days will either make the sheep sick or kill it.

According to Table I where one-quarter pound was fed daily, it

FIGURE 10. A Sheep Down After Eating Spring Rabbit-Brush and Unable to Get Up. This animal died.

FIGURE 11. The Final Result of Eating Spring Rabbit-Brush in Small Quantities for a Prolonged Period or Large Quantities During a Shorter Interval.

took a total of about 3½ pounds to make a sheep sick. In Table II where one-half pound was fed daily it took 2½ pounds to make sick or to kill. In Table III where three-quarters of a pound was fed daily it took 2¼ pounds to make sick and 3 pounds to kill. In Table IV where a full pound was fed daily it took about 3 pounds to make a sheep sick or to kill it.

Taken together, the facts of the whole set of tables show that the poison is eliminated from the body of the sheep so slowly that it takes much the same total amount of the plant to cause severe poisoning whether the plant is fed in small quantities during a period of twelve or more days or is fed in larger quantities over a shorter period.

TABLE V—SHEEP

Daily Feeding of One and One-Half Pounds of the Green Growth of Spring Rabbit-Brush

Animal No.	*Wt. lbs.*	*Date*	*Time*	*Amt. fed lbs.*	*Time symptoms appeared*	*Time of death or recovery*	*Final result*
18	84	5- 9-18	11:20 a.m.	1½			negative
192	76	6- 5-22	2:30 p.m.	1½			negative
344	65	5-25-21	3:15 p.m.	1½			
		5-26-21	7:30 a.m.	1½	10:00 a.m. 5-27	9:00 a.m. 5-30	death
425	80	5-19-18	8:25 a.m.	1½			
		5-20-18	1:10 p.m.	1½	2.45 p.m. 5-22	8:00 a.m. 5-24	death
466	89	6- 1-22		1½			
		6- 2-22		1½			
		6- 3-22		1½	8:00 a.m. 6- 2	6-10	recovery
46	72	5-19-18		1½			
		5-20-18		1½			
		5-21-18		1½	5-23	5-25	death

The figures given in Table V show that a single feeding of 1½ pounds of the spring rabbit-brush will not make a sheep sick; while two or three such feedings on successive days will make a mature range sheep sick or will kill it.

TABLE VI—SHEEP

Larger Daily Feedings of the Green Growth of the Spring Rabbit-Brush

Animal No.	*Wt. lbs.*	*Date*	*Time*	*Amt. fed lbs.*	*Time symptoms appeared*	*Time of death or recovery*	*Final result*
685	101	6- 5-22	3:15 p.m.	2			
		6- 6-22	10:00 a.m.	2	6- 6	8:00 a.m. 6- 8	death
1000	105	3-26-21	1:30 p.m.	2½	3-27	4- 2	recovery
307	102	5-12-21	11:30 a.m.	2½	5-13	5-17	recovery
306	81	6- 6-22	4:30 p.m.	2½			
		6- 7-22	4:30 p.m.	2½	8:30 a.m. 6- 9	8:00 a.m. 6-12	death
72	93	6- 7-22	3:00 p.m.	3	6-11	4:30 p.m. 6-11	death
24	67	5-31-18	10:55 a.m.	3	6- 1	8:00 a.m. 6- 2	death
10	82	5-31-18	11:10 a.m.	3½	8:45 a.m. 6- 1	8:45 p.m. 6- 1	death
702	79	6-21-22	2:00 p.m.	3¾	1:20 p.m. 6-22	7:50 a.m. 6-23	death
708	84	6-21-22	1:30 p.m.	3¾	2:00 p.m. 6-22	10:30 a.m. 6-23	death
689	81	6-20-22	1:30 p.m.	4	9:30 a.m. 6-22	7:50 a.m. 6-23	death
663	67	6-20-22	2:30 p.m.	4	8:00 a.m. 6-22	10:15 a.m. 6-22	death

The figures given in Table VI show that (1) daily feedings of 2 pounds each for two days will kill a mature range sheep; (2) a single feeding of 2½ pounds will make the animal sick; (3) 2½ pounds fed daily for two days will kill; (4) a single feeding of 3 pounds may kill; (5) single feedings of 3½, 3¾, and 4 pounds are fatal.

TABLE VII—CATTLE

Feedings of the Green Growth of Spring Rabbit-Brush

Animal No.	Wt. lbs.	Date	Time	Amt. fed lbs.	Time symptoms appeared	Time of death or recovery	Final result
4	150	4-18-19	10:30 a.m.	1			negative
6	193	4-18-19	10:30 a.m.	2			negative
1	140	5- 2-19	9:30 a.m.	6½			negative
166	181	4-30-21	9:00 a.m.	2			
		5- 1-21	9:00 a.m.	2			
		5- 2-21	9:00 a.m.	2			
		5- 3-21	9:00 a.m.	2			
		5- 4-21	9:00 a.m.	2			negative
165	164	4-21-21	9:00 a.m.	11			negative
1	143	4-18-19	10:00 a.m.	1½			
		4-19-19	11:40 a.m.	1½			
		4-20-19	8:30 a.m.	2			
		4-21-19	10:30 a.m.	3			negative
31	280	6- 4-20	5:00 p.m.	5			
		6- 5-20	9:00 a.m.	7½			
		6- 6-20	9:00 a.m.	4½			
		6- 7-20	9:00 a.m.	3¾			

The figures given in Table VII show how little effect the spring rabbit-brush has upon cattle.

For five days in succession Animal No. 166, a short yearling steer weighing 181 pounds, was fed two pounds daily, a total of 5½ per cent of its live weight. At the end of the five days, to all outward appearance, the animal was perfectly well. Animal No. 31, weighing 280 pounds, was fed a total of 20¾ pounds, or 7.4 per cent of its live weight, in the course of four days, without any apparent harm. In view of the results from the whole set of tests with cattle, it seems clear that under range conditions little or no damage should be expected from this plant.

Conditions Under Which Sheep Are Poisoned by the Spring Rabbit-Brush on the Range.

Under normal conditions rabbit-brush is very distasteful to the average range sheep. However, when sheep are hungry and there is a shortage of other feed, they will eat it, sometimes in large quantities.

A shortage of desirable feed in the spring may occur when the range is partly snowed under by late snows or on range that has been overstocked for a number of years. Good feed will evidently be short where several flocks have been trailed over the same range; for the first bands eat all the valuable feed, leaving nothing for the bands which follow but the distasteful and poisonous plants. Very naturally, too, feed will be short and poisoning may occur where many sheep have been held on a small area of range around dipping plants, shearing corrals, shipping points, and the like. In general, poisoning and death in sheep may be expected on any sheep range where good feed is short for any of the reasons mentioned and there is an abundance of spring rabbit-brush.

Methods of Preventing Losses of Sheep.

Range losses due to this rabbit-brush may be avoided by taking the following precautions: In the first place hungry sheep should not be turned onto or trailed over a range where there is nothing much but the spring rabbit-brush. Likewise, they should not be kept long on range where this form of rabbit-brush is common and the rest of

the feed is so short that they will eat a little of the poisonous brush every day. Then, too, after sheep have been snowed in for several days, it is a good plan to keep them off all rabbit-brush range until their hunger has been satisfied. Around shearing and dipping corrals and near shipping points or after long trips on the cars it is especially important not to hold sheep on rabbit-brush range. These simple precautions will prevent most of the losses.

Remedies.

The effect of rabbit-brush poisoning upon the sheep is so severe that up to date all remedies tested have been a failure.

It Is Important to Know the Plant.

It is evidently of great importance that the herder shall recognize the spring rabbit-brush and know it from all other plants on the range. He should realize that it is poisonous, and he should know the conditions under which sheep will eat it, and the poisoning which is apt to follow.

SECTION II

Preliminary Studies of the Chemistry of the Poisonous Principle of the Plant, with a Detailed Description of the Symptoms and Post-Mortem Conditions in Poisoned Sheep.

THE CHEMICAL NATURE OF THE POISONOUS PRINCIPLE OF THE SPRING RABBIT-BRUSH

A survey of the available literature indicates that little attention has been paid to the chemical composition or to the active principle of this plant. Feeding tests have shown that there is undoubtedly a substance present in the buds which is poisonous to sheep.

Jacobsen reports* having found potash in the ash of the buds of the plant equivalent to 2 per cent of the weight of the green buds; and, in view of the presence of abnormal quantities of potash in the liver, blood, ascitic and pleuritic fluids of the body of sheep poisoned by the plant it appeared that potash might be the cause of the poisoning.

To test this assumption, N. F. Peterson of the Nevada Station fed large doses of potassium chloride to sheep without producing symptoms of poisoning. A sheep weighing 116 pounds was fed 1.28 ounces of potassium chloride; the following day none was given, but on the next day another dose of 1.28 ounces was given. The total quantity of potash fed was as great as that in eight pounds of the green plant, of which it takes less than three pounds to kill a sheep. Still no bad effects followed the administration of the potash. On another occasion Peterson fed to a sheep the following doses of potassium chloride: first day, 50 grams; on each of the next five days, 25 grams; on the seventh day, 30 grams, making a total of 205 grams or 7¼ ounces given without producing symptoms of poisoning. This is equivalent to the potash in more than 22 pounds of the green tips of the spring rabbit-brush.

Recent experiments have indicated that potash is not the cause of poisoning; and that some organic material, probably of a resinous nature is responsible. The following paragraphs give a summary of the work done recently in an attempt to isolate the poisonous principle.

An essential oil was first extracted from the buds and tested for poisonous properties. The buds, either dried or fresh, have a penetrating aromatic odor peculiar to the plant, suggesting the presence of an essential oil. In order to obtain this oil a quantity of the dried-and-ground buds equivalent to 331.5 grams of fresh material was steam distilled until no further oil could be seen in the distillate.

Small drops of the oil could be observed floating on the surface of the distillate. To collect the oil the distillate was extracted with ether and the ether evaporated at a low temperature leaving the essential oil. By this means 0.5219 grams of oil were obtained, equivalent to 0.157 per cent of the green weight of the plant used. The oil was brownish-yellow, rather viscous when cold and with the characteristic odor of the plant. In order to test its poisonous properties, 0.1975 grams of the oil, a quantity equivalent to 125 grams of the fresh plant, was given in a gelatine capsule to a rabbit weighing 2,360 grams. No symptoms of poisoning followed.

Some buds very recently air-dried and ground were steam distilled and there was obtained a quantity of oil equivalent to 0.133 per cent of the weight of the green plant. Of this oil, 0.4824 grams were suspended in water and diluted to 50 cc. This was given to a rabbit weighing 2,500 grams by means of a stomach tube in the following doses: first three days, 10 cc each day; the fourth day none; and 10 cc on the fifth day. Each 10 cc of the emulsion represented 288 grams of the

*Nevada Station, Annual Report for 1917, pp. 60-61.

fresh plant. The rabbit showed no symptoms and remained in good condition. The volatile oil obtained by steam distillation of the fresh plant was also administered by N. F. Peterson to a sheep, but without results. From these experiments it would appear that the volatile constituents of the plant do not contain the poisonous principle.

In order to determine whether alkaloids are present in the green parts of the plant, a chloroform extract of the ground fresh buds was made which yielded 1.11 per cent of extractives. The residue from evaporation of the chloroform was treated with dilute sulphuric acid, and the acid solution was tested with the common alkaloidal reagents, but with negative results in each case. The dry plant was macerated with dilute sodium hydroxide and steam distilled. The distillate gave no reaction with silver nitrate, ferric chloride, or any of the alkaloidal reagents. Another portion of ground air-dried plant was macerated and extracted with water acidified with sulphuric acid. The acid aqueous extract gave no reactions for the presence of alkaloids with the common reagents.

As the poisonous character of this rabbit-brush is apparently due to neither the essential oil nor to alkaloids, extracts were made with several standard solvents, and their properties were tested in order to establish a method by which the active principle might be isolated.

One hundred grams of buds, which had become wilted in the laboratory, were ground up and completely extracted with petroleum ether. The solvent removed 1.30 per cent of the fresh weight of the plant. The substance thus removed was of a yellow color with a slightly bitter taste and characteristic odor; the texture was sticky and resinous. A capsule was filled with 0.4520 grams of the residue equivalent to 34.7 grams of the fresh plant and fed to a rabbit weighing 1,340 grams. The animal was etherized to facilitate administration. A second capsule was prepared containing 0.440 grams. On the following day a second capsule containing 0.440 of the residue was given in the same manner; but the animal collapsed under the anesthetic.

In the light of the observed action of the plant it was suggested that perhaps the dose administered had helped to cause the animal's death.

One hundred grams of the ground recently dried buds equivalent to 292.4 grams of fresh material were extracted with petroleum ether. The evaporation of the solvent left 3.4352 grams of residue or 3.43 per cent of the dried material, or 1.17 per cent of the green plant. This was emulsified and suspended in water. A portion of the suspension corresponding to 25 grams of air-dried or 73.0 grams of the green plant was administered to a rabbit weighing 1,550 grams by means of a stomach tube. On the second day another portion equivalent to the same quantity was given in the same manner, and on the third day a third dose was given. The animal was found dead on the morning of the fourth day. An autopsy showed many changes of the same character as those found in sheep poisoned by the plant.

The petroleum ether extracted plant was then extracted with ether which on removal of the solvent showed 0.9614 grams to have been removed. The ether had extracted 0.96 per cent of the air-dried plant or 0.32 per cent of the green material. The extracted substance was suspended in water; the equivalent of 73.1 grams was given by stomach tube to a rabbit weighing 1,760 grams, each day for two successive days; the next two days none was given, and on the following

two days two more daily doses equivalent to 73.1 grams of the green plant were given. The animal showed no symptoms of poisoning, but continued to eat and remained in good condition.

A chloroform extract was next prepared from the plant residue from the ether extraction. Chloroform removed 2.3052 grams of material or 2.30 per cent of the dry plant or 0.78 per cent of the green material. Three doses of a suspension of this extract, representing 73 grams of fresh material, were given by stomach tube to a 2,500-gram rabbit without result.

The acetone soluble material was next removed and there was obtained 6.752 grams of 2.30 per cent of the original plant. This was suspended and given to a rabbit weighing 2,210 grams by means of the stomach tube. There was no apparent reaction until the sixth day after the final administration, when the animal was found dead. Autopsy disclosed noticeable venous engorgement of the peripheral vessels, serous vessels of the peritoneum and abdominal viscera. There was passive congestion of the lungs, one hemorrhagic infarct in the left lung. Subserous hemorrhages were absent entirely. Death was apparently due to cardiac failure.

An alcoholic extract was prepared from buds which had been air dried and kept in an open box for about three months. The extract was shaken out with several portions of carbon bisulfide which removed 20.75 per cent of the solids of the alcoholic solution. The material dissolved out by the carbon bisulfide, representing 75 grams of green plant, was suspended and given by stomach tube to a rabbit on three successive days without result. The material not dissolved by the carbon bisulfide was likewise tested without result.

Another sample of the dried buds which had been on hand some time was extracted with petroleum ether. The petroleum ether was removed and the residue was treated with 80 per cent alcohol. Of the petroleum ether residue, 58.37 per cent was dissolved and removed by the alcohol. The alcohol-soluble part was suspended and administered in the usual way in three daily doses without effect. The part insoluble was likewise suspended and administered without action. The proportion of extract used in this was comparable to those of the other experiments.

Conclusions.

These preliminary experiments indicate that in the fresh plant and in the freshly dried plant there are substances which may be removed by petroleum ether which have an action on rabbits similar to that of the plant upon sheep; also, that there is probably another substance present, removable only by acetone, which has a physiological action.

It is also indicated that the active material of the fresh plant soluble in petroleum ether is modified or destroyed when the buds stand in the dried state for a short time, with the result that the petroleum ether extract is no longer toxic to rabbits. That this is not lost by volatility is shown by the fact that the volatile material from the fresh plant is not toxic.

From the appearance of the petroleum ether extract it is probable that the toxic material is resinous in character. Further experiments on fresh plants, when they are again available, may show what the toxic material really is, now that it is known by what solvent it may be removed from the plant.

SYMPTOMS OF POISONING AND POST-MORTEM CONDITIONS

Methods of Feeding.

Sheep and cattle used for feeding experiments on this plant were fed in two ways:

1. Administration of the entire test dose of the plant at one feeding.
2. Fractional Feeding. This was begun after the lethal dose had been determined, and consisted of dividing the lethal dose into equal fractional amounts and one fraction fed daily until the entire lethal dose was consumed.

In some cases the daily dosage was as low as one-fourth pound, which spread the feeding over a period of twelve to fourteen days. In other cases the daily feedings were three-fourths to 1½ pounds for a period of two to five days.

Symptoms.

Animals fed an entire test dose at one feeding and which later developed symptoms of intoxication usually exhibited definite manifestations in twenty-four to thirty-six hours.

Animals fed a lethal dose in fractional amounts during a period of two to five days usually manifested symptoms in about twenty hours. This was slightly earlier than in the case of animals which had been fed an entire lethal dose at one feeding.

When the feeding period was prolonged to twelve or fourteen days and the daily fraction fed was small, symptoms of intoxication were usually noticeable either three to five hours previous or very soon after the last fractional dose was fed.

The first symptoms usually observed were refusal of food and slight salivation. These symptoms were followed by irregular twitching of muscle groups of the shoulders and neck. As the intoxication becomes more pronounced, the gait becomes unsteady, and incoordination of the limb movements is observed.

The pulse becomes rapid, attaining a rate as high as 135 to 140, and very thready. Elevation of temperature appeared in all animals, but only 1 or 2 degrees as a rule.

In the cases of animals which were fed lethal amounts of the plant the foregoing symptoms were followed by prostration, labored respiration, coma, and death. Death was due to cardiac failure after an illness of twenty-four to thirty-six hours.

In a few instances animals lingered as long as three days. Animals fed small amounts of the plant for several days manifested a decidedly shorter duration of illness, death ensuing in ten to eighteen hours after the first appearance of clinical symptoms.

Treatment.

Attempts to treat this condition clinically were made on three animals without success. Further work along this line is contemplated.

Necropsy.

The necropsy observations may be subdivided into two headings. namely, those observed in animals fed a lethal dose at one or two

feedings and, second, animals fed fractional portions spread over a period of several days.

In instances wherein the lethal dose had been administered at one or two feedings, the necropsy observations were as follows:

Extensive aggregations of punctate hemorrhages were observed in the subcutaneous connective tissue in the intermandibular region, sides of the neck, in the peritracheal connective tissue and upper costal area. The lymphatic glands of the above areas were hemorrhagic. Pronounced venous engorgement of the subcutis and abdominal and thoracic viscera was fairly constant in all cases.

The small intestines usually manifested a variable degree of catarrhal enteritis with scattered areas of congestion. A very decided odor of *Tetradymia* was apparent upon opening the rumen. The liver in acute cases or those receiving the entire lethal dose in one to three feedings exhibited slight increase in size, red and yellow mottled appearance and friable. Passive congestion was a constant observation, and in a number of cases rupture of the liver capsule had occurred as a result of passive hepatic engorgement with resultant fatal hemorrhage into the abdominal cavity. One case of rupture of mesenteric veins was observed.

The bile was slightly turbid.

The kidneys exhibited a low-grade parenchymatous nephritis.

The urine was normal in appearance. In some cases petechial hemorrhages were noticed on the diaphragm. The lungs uniformly manifested severe passive congestion and marked venous engorgement of the bronchial and tracheal mucosa.

The heart exhibited subepicardial petechial hemorrhages along the auriculo-ventricular border and course of coronary vessels. The heart manifested acute albuminous degeneration.

In animals fed fractional doses for a period as long as twelve to fourteen days, the necropsy observations were approximately the same as in the foregoing except in the case of the liver. This organ manifested a brownish-yellow color, little change in size but friable, and a decided appearance of fatty degeneration. A few cases presented the appearance of beginning fibrosis due to the long continued presence of this toxic substance in the food.

Conclusions.

The toxic principle in *Tetradymia* appears to be cumulative in action as demonstrated by fractional feeding experiments. The clinical observations fail to present sufficiently defined symptoms by which a positive diagnosis of *Tetradymia* poisoning may be made. Necropsy examinations disclosing extensive subcutaneous hemorrhages and petechial hemorrhages on the heart, together with the fatty degeneration of the liver and characteristic aromatic *Tetradymia* odor which arises upon opening the rumen, may be interpreted as characteristic of fatal intoxication by this plant. Additional history of animals having pastured on *Tetradymia glabrata* areas before death should be obtained before making a positive diagnosis.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 105 RENO, NEVADA April, 1923

To diminish suffering and loss among domestic animals

THE LOW LARKSPUR

(*Delphinium andersoni*)

A Plant of the Spring Range, Poisonous to Cattle

By

C. E. FLEMING
Of the Department of Range Management

Assisted by

M. R. MILLER
Of the Department of Chemistry

and

Dr. L. R. VAWTER
Of the Department of Veterinary Science

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
State Printing Office—Joe Farnsworth, Superintendent
CARSON CITY, NEVADA

1 46

NEVADA AGRICULTURAL EXPERIMENT STATION

Small Larkspur (Delphinium Andersoni)

SUMMARY

(1) The low larkspur is a common poisonous plant of the spring range in eastern Oregon, California, and Nevada. It is poisonous to cattle, but not to sheep, and causes the death of many steers and cows every spring.

(2) It is closely related to the larkspurs grown in flower gardens, and has much the same appearance. The leaves seem ragged because they are made up of irregular divisions radiating from the center. The plants come up very early in the spring in little green clumps of leaves here and there among the rocks and sagebrush. Later in the spring the deep-blue flowers shoot up above the leaves in one or more spikes from twelve to eighteen inches high.

(3) They go to seed, and the plant then dies down to the ground in the warm days of early summer, but comes up again from the same root for several years.

(4) This larkspur grows in sandy or gravelly soil in the sagebrush country of the foothills and the lower slopes of the mountains.

(5) There is no known cure for poisoning by the low larkspur; in fact, the dose which causes illness is so nearly the fatal dose and the action of the poison is so prompt that there is usually little opportunity for the administration of remedies.

(6) Experimental feedings to steers showed that it takes from 20 to 25 pounds of the leaves and flowers of this larkspur to poison seriously or to kill a thousand-pound animal in good condition. Weak and half-starved cattle are probably poisoned by considerably smaller quantities.

(7) Most of the cases of poisoning by this plant are due to the fact that the ranges where it grows have been overgrazed and overstocked to such an extent that the cattle are obliged to eat worthless or poisonous plants or else go hungry. Normal cattle in good health ordinarily prefer grass to larkspur.

(8) The only hope of prevention is in giving the grass a chance to come back on any overgrazed foothill ranges which may be under control and in keeping weak and hungry cattle off larkspur ranges in the early spring.

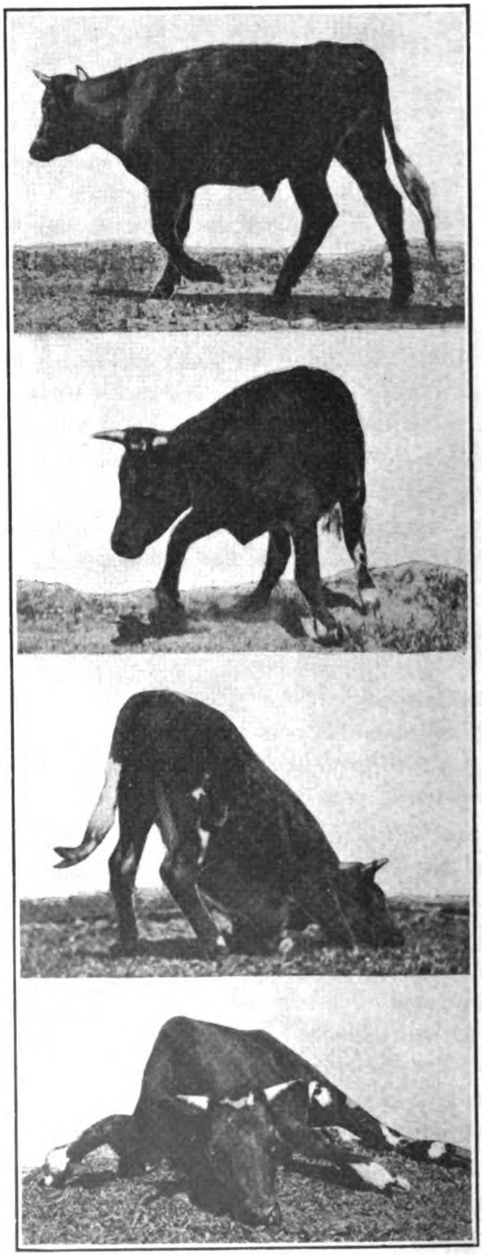


FIGURE 1
A Fatal Case of Larkspur Poisoning

SECTION I

THE LOW LARKSPUR

(Delphinium andersoni)

A Plant of the Spring Range, Poisonous to Cattle

Of all the poisonous plants found on the ranges of eastern Oregon and California and western Nevada the larkspurs probably cause the heaviest losses. They poison large numbers of cattle every spring;

FIGURE 2. A Larkspur Plant on the Range. This is the stage of growth in which it is most dangerous.

and many of the losses are avoidable. It is the purpose of this bulletin to give stockmen a clear idea of the appearance and character of one of these deadly plants, the common low larkspur of the spring range.

As soon as the snow leaves the foothills, the fresh green leaves of this larkspur push through the soil in clusters here and there. They

are often out in February; and in March and April on overgrazed ranges they are abundant enough to make up far too large a part of the forage.

The fresh green leaves have a rather ragged appearance, because each leaf consists of a number of partly separate divisions radiating from the center like the spokes of a wheel. From the clump of leaves a single flower-stem grows up to a height of from a foot to eighteen inches. The leaves are dark-green, the leaf-stems purplish, the flowers are of a rich blue with yellow centers. Each single flower grows on its own tiny stem; there are five deep-blue petals; and the back of the flower projects into a short blunt tail or spur which gives the flower its name.

Other Plants Commonly Mistaken for Larkspur.

On the range there are several other plants which men handling live stock are apt to mistake for the low larkspur.

These plants are the waterleaf, and occasionally the lupine in its early stages of growth.

Figure 3 shows a growing lupine plant. The leaf is made up of several perfectly formed leaflets not much like the irregular divisions of the larkspur leaf. Figure 4 gives outline drawings of typical leaves of lupine, larkspur, and waterleaf.

The waterleaf resembles quite closely the low larkspur before either has come into bloom. These two plants may be easily distinguished from each other by comparing the leaves as in Figure 4.

Regions and Soils Where the Low Larkspur Grows.

The low larkspur dealt with in this bulletin is found in southeastern Oregon, Nevada, and California.

The mountain foothills and the bordering sagebrush range form the typical country of this small larkspur. It prefers a well-drained soil, not excessively moist, usually a sandy loam. Unlike some other kinds of larkspur it grows in full sunlight. Thus it is found in the open areas between the sagebrush bushes or right next to the sagebrush plant. It has not been found in the shady groves of quaking aspen and alder where some of the tall larkspurs grow.

Later in the season in the higher mountains this low larkspur may be found growing abundantly in the open park-like country. However, most of the cattle poisoned by it die in the spring on the sagebrush range adjoining the higher mountain areas. The sagebrush is the plant with which it is most commonly associated.

Seasonal Growth.

The low larkspur makes all of its growth during the spring and early summer months. It is very unusual to find any of the plants in a green growing condition after the middle of June. In the foothills it is just coming into bloom by the first of May in normal years. By the middle of May the lower leaves begin to fade and turn yellow; the seeds are soon matured, and the upper part of the plant dies and soon disappears.

Fortunately the period during which it may cause livestock losses is of short duration. On the other hand, the larkspur commences its

spring growth at least as early as any other range plant and consequently it is found in abundance at a time of year when other vegetation is short and scanty. Thus it constitutes a much-dreaded hazard on many of the early spring livestock ranges.

In general, it may be said that this low larkspur is essentially an early blooming and early maturing plant. It soon dies to the ground and ceases to be dangerous after producing flowers and seeds.

Animals Which Are Poisoned.

All our experimental feedings with this low larkspur indicate that it is not poisonous to sheep.

Under ordinary range conditions, horses do not relish any kind of

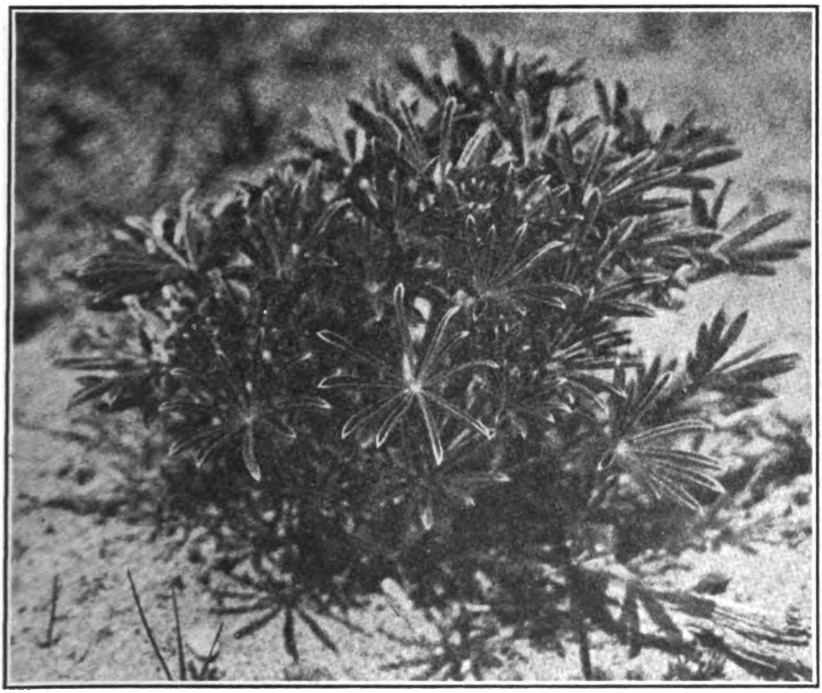


FIGURE 3. A Clump of Lupine Leaves in Spring. Sometimes mistaken for the low larkspur.

larkspur; for which reason they seldom eat enough at one time to cause serious trouble. Therefore it cannot be classed as an important source of danger to horses.

In the northern half of the State of Nevada more losses of cattle are caused by the two kinds of larkspurs, "low" and "tall," than by any other plants. In the southern half of the State the loco-weeds probably rank first. Wherever cattle are turned upon a range supporting an abundance of larkspur and only a little grass, losses will probably take place. This is particularly true if the range has been closely grazed or overgrazed.

Probability of Poisoning.

In the experimental feeding tests where large quantities of the plant were weighed and placed before cattle it was observed that the low larkspur is much more attractive to some cattle than to others. Some animals would readily and quickly eat a quantity of it sufficient to kill. Others, after days of starvation, would eat it only in small quantities, quite insufficient to do them harm. Then there were others which would eat it in quantities which would make them sick, but would not kill.

These tests seem to indicate that on the range the danger from larkspur poisoning depends not entirely upon the abundance of the plant,

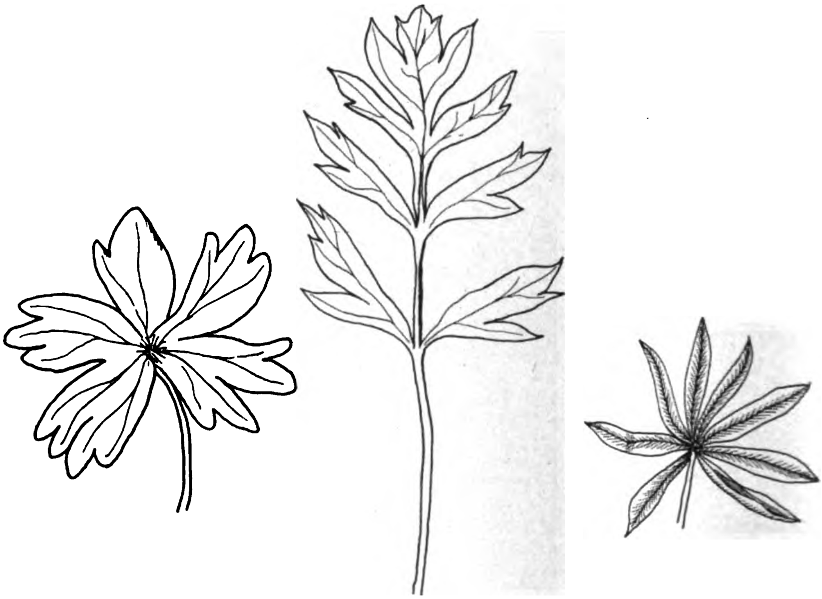


FIGURE 4. Leaves of Larkspur, Waterleaf and Lupine. The larkspur leaf (on the left) is of a different structure from that of the waterleaf (in center) or the lupine (on the right).

but also upon the condition of the cattle and the number of them which do not dislike larkspur as well as upon the condition of the range.

The Time of Year When This Larkspur Is Dangerous.

All of the feeding tests which we have made with this plant show that cattle may be poisoned by it, from the time when the plants are sufficiently large to be grazed until they turn brown and begin to wither. It appears to be a little more poisonous before blooming than after it is in full bloom.

The Part of the Plant Which Is Dangerous.

The experimental feeding tests made during the past three years show that leaves, stems, flowers, and pods are poisonous, but that under range conditions the roots are not dangerous.

In the spring of 1919 a young steer weighing 312 pounds was fed 2 pounds of roots on May 2, and 3 pounds on May 3, without any bad effects.

On April 28, 1921, a small steer weighing 287 pounds was fed 3¼ pounds of roots; on April 29, 3 pounds; and on April 30, 2½ pounds—a total of 8¾ pounds. Apparently this quantity of roots caused no harmful effects.

It was with great difficulty that the steers were made to eat such a quantity of the roots, for they were decidedly distasteful—so much so that it appeared very improbable that range animals would ever voluntarily eat a poisonous dose.

On a sandy soil, where the principal vegetation consisted of sagebrush and low larkspur, ten large dead steers were found which had been fatally poisoned by eating this plant. The loose top soil was made up mainly of sand; still, with only a few exceptions, the larkspur plants had been grazed without the root system being pulled out of the ground. The few roots which had been pulled up by the cattle had not been eaten, but had been left in a somewhat mangled condition.

FIGURE 5. A Waterleaf Plant in May. In the spring this plant looks much like larkspur, but the leaves are different and the pale lavender flower grows close to the ground.

The results of the feeding tests with roots and the way in which they are rejected by cattle show that it is the tops and not the roots which cause poisoning.

Amount Necessary to Poison Cattle.

The following feedings were made with green, partly wilted larkspur plants. The average length of time that it took the animals to eat the amounts of larkspur recorded for each animal in the following table was from an hour and a half to three hours:

FIGURE 6. The Low Larkspur in Full Bloom.

TABLE I

Low Larkspur—Fresh Green Early Growth Fed to Cattle

Animal No.	*Wt. lbs.*	*Stage of growth*	*Amt. fed, lbs.*	*Pounds fed per 100 lbs. animal wt.*	*Final result*
5	208	Before blooming	2½	1.20	negative
1	136	Before blooming	2	1.47	negative
6	203	Before blooming	2½	1.23	negative
5	208	Before blooming	2½	1.20	negative
23	198	Before blooming	2¾	1.38	negative
1	136	Full bloom	2	1.47	negative
5	217	Full bloom	2¾	1.26	negative
6	209	Full bloom	2¾	1.31	negative
23	215	Full bloom	2¾	1.27	negative
91	542	Before blooming	10	1.84	recovery
63	646	Before blooming	16¾	2.59	recovery
2	157	Before blooming	3	1.91	recovery
3885	612	Full bloom	16	2.61	recovery
3888	640	Full bloom	16	2.50	recovery
3883	605	Full bloom	16½	2.72	recovery
3889	750	Full bloom	16	2.13	recovery
63	646	Full bloom	16⅔	2.58	recovery
3881	653	Before blooming	10⅔	1.64	death
7	388	Before blooming	10	2.57	death
9	661	Before blooming	15	2.26	death
10	602	Full bloom	15	2.49	death
3	191	Full bloom	5	2.61	death
4	212	Full bloom	5	2.35	death
3882	590	Full bloom	16¼	2.75	death
2	157	Full bloom	3½	2.22	death

In this table there are nine feedings which had no visible poisoning effect upon the animal. Of the nine feedings, five were made with larkspur plants before they had come into blossom and four with plants in full bloom. From the results of these it seems improbable that poisoning will occur when animals in good condition eat as little as 1.31 pounds of green larkspur per hundred pounds of body weight; that is, a thousand-pound steer should apparently be able to eat 13 pounds of larkspur without any bad effects. A weak, half-starved animal would probably be poisoned by a smaller quantity of larkspur.

The table also shows eight feedings which caused symptoms of poisoning from which the animals soon fully recovered. To produce these symptoms it took as an average 2.11 pounds of green larkspur without flowers and 2.51 pounds of larkspur in blossom per hundred pounds of animal weight, or 20 to 25 pounds for a thousand-pound animal.

Of the eight fatal feedings, three were made with the plants in full bloom and five with plants which had not come into bloom. For the plants not in bloom it required 2.15 pounds of green larkspur per hundred pounds of animal weight to cause death; and for the plants in full bloom, 2.48 pounds. These figures are nearly the same as those given for cases where the poisoned animals recovered; and it is very evident that there is but little difference between a fatal dose of larkspur and a quantity which will make the animal sick but will not kill it. To kill a range cow or steer weighing 1,000 pounds it would take from 21 to 25 pounds of the small larkspur. This seems like a large amount, but when it is understood that the green larkspur plants

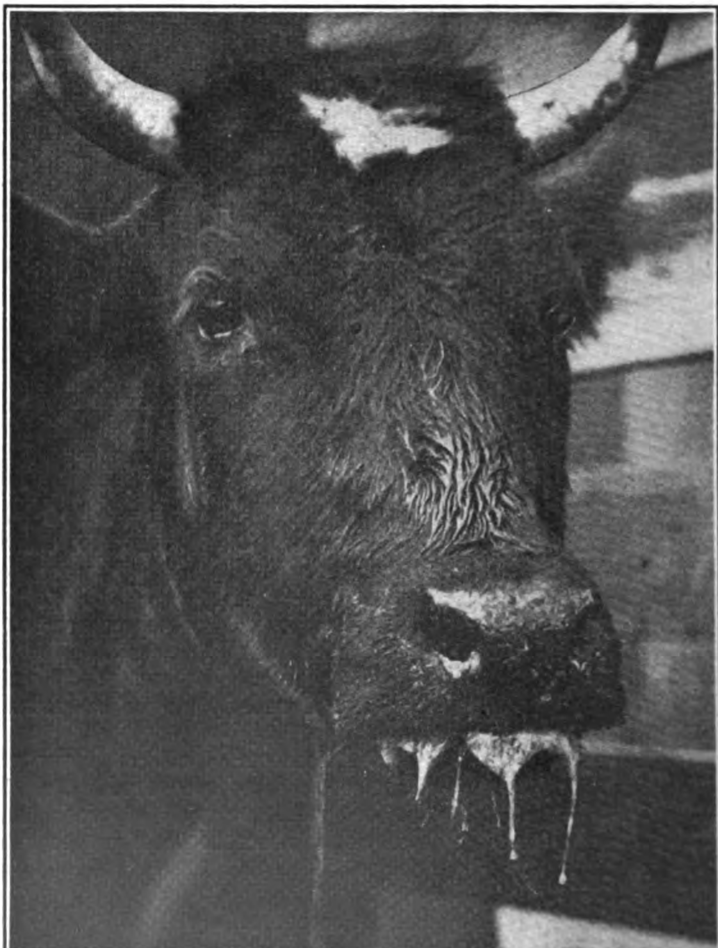


FIGURE 7. Head of a Steer Poisoned by Larkspur. Drooling is a common symptom of larkspur poisoning.

are heavy with moisture it is evident that a steer or cow on the range can easily and quickly gather such a quantity.

The feeding experiments also show that the larkspur plant is a little less poisonous after it comes into full bloom; for it takes three or four pounds more of the plant in full bloom than of the leaves and buds to kill a thousand-pound range cow or steer.

The difference is of little or no practical importance in view of the fact that soon after blooming the low larkspur of the sagebrush country matures and disappears.

Feeding Tests with Sheep.

For many years it was believed by a majority of sheep men that the larkspurs were poisonous to sheep. At one time the larkspurs were given wide publicity as being responsible for losses of sheep, especially during the early spring months. However, in recent years it has been quite firmly established that the larkspurs are not poisonous to sheep. In order to remove any doubt about the matter, the low larkspur of western Nevada was fed to sheep in a number of experiments whose results are given in the following table:

TABLE II

Low Larkspur—Fresh Green Early Growth Fed to Sheep

Animal No.	*Wt. lbs.*	*Part of plant fed*	*Date fed*	*Amount fed, lbs.*	*Amount per 100 lbs. animal wt.*	*Final result*
29	104	Stems and leaves	3-28-19	4	3.84	bloated
29	101	Stems and leaves	4- 2-19	5½	5.44	bloated
536	85	Stems and leaves	4-26-22	2½	2.94	negative
537	90	Stems and leaves	4-26-22	2½	2.77	negative
342	98	Stems and leaves	4-28—5- 3	24	24.48	negative
1003	96	Stems and leaves	4-24—4-30	21	21.87	negative
1004	102	Stems and leaves	4-24—5- 3	30	29.41	negative

Aside from a slight loss in weight all of the six sheep used in these experimental feeding tests showed no bad effects from eating the larkspur. Animal No. 29 was fed 4 pounds on one day and 5½ pounds a few days later by a forced feeding method. On each occasion these forced feedings caused bloat; but this would probably have occurred if the same quantity of any other green plant had been fed. Animals Nos. 536 and 537 which were fed smaller quantities than No. 29 showed no ill effects. Sheep No. 342 was fed 24 pounds in 6 days; sheep No. 1003, 21 pounds in 7 days; and sheep No. 1004, 30 pounds in 10 days without any injurious effects.

During the spring of 1922 three bands of ewes and lambs were observed grazing on a range where this small larkspur was growing in considerable abundance. The other plants were sagebrush, grasses, and a scattering growth of weeds. After grazing for about two weeks on this range the larkspur, along with the grasses and weeds, had been almost completely removed. In two weeks not one case of poisoning in ewes or lambs occurred on this range.

These range observations and the feeding experiments make it seem clear that the small larkspur is not poisonous to sheep.

Symptoms of Poisoning Among Cattle.

On the range the first symptom of larkspur poisoning is the falling of the animal. An animal which goes down for the first time almost

always gets up, only to fall again after walking a short distance. After going down the first time the animal usually walks about with the hind legs spread quite widely apart and with a more or less staggering movement. There is little or no action in the joints of the legs, the walking movements being extremely stiff.

There are two ways in which the poisoned steer or cow may go down: It may collapse and fall suddenly because all four legs give way at once; or the front legs may give out first and the animal may then keep itself from going clear over by resting the chin or the side of the head on the ground. In this position the hind legs are usually spread quite far apart, and then from this position the animal goes completely down. In some cases it lies flat on the ground, sometimes raising the head up and down; and often the whole body lies extended with little or no muscular movement taking place. In less

FIGURE 8. A Steer Killed by Larkspur. This is a common sight on any larkspur range where cattle graze.

acute cases it will lie with its head erect. Frequently when standing there is a pronounced quivering or muscular trembling over most of the body, especially noticeable in the muscles around the nose and mouth. The spasmodic contortions of the muscles are also very clearly seen around the shoulders, hips, and flanks. There is often a belching of gas and an attempt on the part of the animal to vomit. Frequently there is drooling or slobbering; although this is not characteristic, and the drooling is not nearly so profuse as in cattle poisoned by the death camas. Constipation is almost invariably present and is rather acute.

Methods of Prevention of Losses.

The low larkspur described in this publication differs greatly in its habit of growth from the tall larkspur. It grows on the lower sagebrush ranges, scattered thinly here and there in the open spaces; but the tall larkspur grows in dense clumps or masses, often in the shade of alders or quaking aspens. The clumps of tall larkspur may profitably be grubbed out, but the small larkspur is too scattered to make grubbing practicable. Although sheep are not poisoned by the small larkspur, they cannot be used to clean it up before cattle go on a piece of range, because the amount of forage found on most of the low lying sagebrush country where this plant grows is usually very limited and scanty, and after the sheep have passed over there is little or nothing left for cattle.

There are many fenced enclosures on the early spring grazing grounds where this larkspur grows abundantly. Cattle are turned into these enclosures shortly after the snow leaves in the spring and under these conditions losses have occurred. The fatal results were due to the fact that hungry cattle were confined to a small area where they were forced to eat the small larkspur. It is evidently very dangerous to turn cattle on spring range under fence when the grass is short and larkspur is abundant. For example, ten large two-year-old steers were killed in a short time on such pasture before the remainder of the animals were removed. There was still enough larkspur left in the pasture to have killed between 50 and 75 large steers. There was so little grass on this piece of spring range that more losses would certainly have occurred if the animals had not been removed.

In the spring many of the stock cattle are skin poor. Their winter rations have been scanty and often of a constipating nature. The prolonged scanty ration has produced an abnormal appetite. These weak cattle, ravenously hungry for green feed and already more or less constipated, are put on range full of the very constipating and poisonous larkspur, green and fresh. Other feed is scanty, and fatal poisoning is almost certain to take place—losses which would probably not occur were the animals in a fair condition of flesh with normal appetite and bowels working regularly.

After cattle have been kept for so long a time on coarse dry feed that they are weak and hungry, they will eat many plants which they will scarcely touch when they are full-fed and in good condition. On ranges where there is plenty of grass along with the larkspur, poisoning is not likely to occur, even though the larkspur plant is present in abundance.

Overstocking and overgrazing are the real causes of larkspur poisoning. Ranges formerly valuable become dangerous when the most palatable and nutritious plants are removed and destroyed, leaving those which are worthless or actually poisonous. Spring range on which grass is nearly gone, but larkspur is abundant, should not be grazed by hungry cattle if this can possible be avoided.

SECTION II (Technical)

Facts Concerning This Low Larkspur Which Are of Special Interest to Chemists and Veterinarians

ALKALOIDAL CONTENT OF DELPHINIUM ANDERSONI

A number of species of the larkspurs have been investigated and have been found to contain crystalline and amorphous alkaloids. Plants which are closely related to each other, species of the same genus, often contain similar substances and show much the same properties. For this reason it seems probable that *delphinium andersoni* contains alkaloidal poisons similar to those found by investigators in other larkspurs.

The physical properties of the poisons obtained by Beath (J. Am. Pharm. Assoc., 7, 1918, 955–958) from *D. geyeri* (low) and *D. subalpinium* (*D. barbeyi*) (tall) show striking resemblances. *Delphinium geyeri* yields amorphous alkaloidal products only, while *D. subalpinium* yields a crystalline alkaloid only in the early stages of growth. It was reported by this author that the crystalline alkaloids combined with an acid similar to aconitic acid to form an amorphous alkaloidal product, the toxicity of which was greater than that of the crystalline alkaloid. *Delphinium geyeri* was found to contain crude alkaloids to the extent of 1.5 per cent in the leaves and stems of early growth. The mature stems and flowers contained 0.7 per cent of crude alkaloids. *Delphinium subalpinium* contained smaller quantities, viz, 0.7 per cent crude alkaloids in the early growth and 0.3 per cent in the mature leaves, stems, and flowers.

Delphinium nelsoni was reported by Loy, Heyl and Hepner (Wyoming Agr. Exp. Station, 23d Ann. Rep. 1913, 73–79) to contain crude alkaloids as follows: flower, 0.79 per cent; pod, 0.60 per cent; seed, 1.27 per cent; leaf, 0.54 per cent; and root, 0.49 per cent. In *D. glaucum* there was found: flower, 0.77 per cent; leaf, 0.62 per cent; and root, 1.79 per cent. In *D. geyeri* there was found: leaf and stem, 1.15 per cent; and root, 0.93 per cent.

A portion of a lot of larkspur collected for one of the feeding tests was set aside for the determination of alkaloids. Assays were made by three methods, (a) U. S. P. method (U. S. Dispensatory, 19th Ed. p. 228) for the assay of belladonna leaves, (b) the method used by Beath (Wyoming Agr. Exp. Station Bul. 120, 1919, p. 71), and (c) the method of the Bureau of Plant Industry (Bur. Plant Industry Bul. 102, Part VII) which was devised for the determination of nicotine. Moisture determinations having been carried out on the air-dried powdered plant material, the percentages of alkaloids found have been calculated to a water-free basis. The alkaloids were calculated to delphinin ($C_{31}H_{49}O_7N$). The results obtained by these methods were as follows:

No.	*Method*	*Alkaloids*
1	(a)	1.75%
2	(a)	1.76%
3	(a)	1.64%
4	(b)	1.90%
5	(c)	0.91%

The Bureau of Plant Industry method, originally devised for nicotine, is apparently unsuited for the determination of the alkaloids in this plant, as indicated by the low results obtained. It is probable that the difficulty of complete extraction of the alkaloids by the ligroin

(petroleum ether was used instead) by the method recommended is largely responsible for the low figure.

The content of alkaloidal material of *D. andersoni* is comparable with that found for *D. geyeri* as reported by Beath.

Clinical Symptoms.

Unmistakable symptoms of illness as result of feeding toxic amounts of larkspur (*Delphinium andersoni*) appeared in fifteen cattle in from three to twenty hours. In several instances, however, the exact time of occurrence was not determined because they first appeared some time during the night and the animals were found to be visibly affected early the following morning.

The majority of animals manifested definite clinical symptoms in four to ten hours after ingesting lethal amounts of the plant.

The duration of toxemic symptoms in six animals that died was from three and one-half to five and one-half hours. Two animals developed symptoms and died during the night without being observed.

In eight animals which were poisoned but recovered, the symptoms persisted from seven hours to two days. These animals usually were perceptibly off feed for twenty-four hours after respiratory distress and incoordination subsided.

A clinical record is given as an example. A two-year-old red shorthorn steer (No. 3883, weighing 600 pounds) was fed 16½ pounds of the whole plant (leaves, buds, and stems) between 1 and 4 o'clock in the afternoon of May 16, 1922. Observation on this animal was maintained until late in the evening. At 8 o'clock in the morning of May 17 incoordinate movements in the hind legs were evident.

8:45 a.m. The animal dropped to the ground.

9:00 a.m. Temperature 101.5. Pulse 60. Respiration 89. Animal quiet.

9:20 a.m. Temperature 100.9. Pulse 55. Respiration 24. Recumbent.

9:40 a.m. Temperature 100.8. Pulse 70. Respiration 54.

9:45 a.m. Temperature 100.7. Pulse 68. Respiration 101. Animal restless, respiration labored, futile attempt made to rise.

9:50 a.m. Temperature 100.7. Pulse 62. Respiration 115.

9:55 a.m. Temperature 100.9. Pulse 60. Respiration 113. Distinct twitching of gluteal, scapular, and cervical muscle groups.

10:21 a.m. The animal arose after great effort, walked about ten yards with incoordinate gait, then broke down in the hind legs and fell with fore legs spread apart.

10:22 a.m. Temperature 100.9. Pulse 60. Respiration 86.

10:30 a.m. Temperature 100.8. Pulse 60. Respiration 116. Muscle twitching again present.

10:45 a.m. Temperature 101.9. Pulse 62. Respiration 80.

11:00 a.m. Temperature 102.3. Pulse 60. Respiration 104.

11:15 a.m. Temperature 102.2. Pulse 63. Respiration 144.

11:40 a.m. Temperature 101.0. Pulse 58. Respiration 148. Animal restless and struggling. Respiration very shallow and rapid, largely through the mouth, and cheeks ballooned. Bloat was well marked, and cyanosis of visible mucous membranes was observed.

11:50 a.m. Temperature 98. Pulse 59. Respiration 148.

12:25 p.m. Temperature 98.6. Pulse 60. Respiration 140.

1:05 p.m. Temperature 100. Pulse 70. Respiration 144.

1:35 p.m. Temperature 101.4. Pulse 90. Respiration 130.

2:35 p.m. Temperature 105.0. Pulse 70. Respiration 135.

3:05 p.m. Temperature 104.2. Pulse 85. Respiration 138. Animal straining in effort to defecate and anus protruded.

3:35 p.m. Temperature 103.4. Pulse 84. Respiration 124.

4:00 p.m. Temperature 103.0. Pulse 74. Respiration 110.

4:45 p.m. Temperature 102.4. Pulse 60. Respiration 98.

5:15 p.m. Temperature 102.0. Pulse 60. Respiration 100.

5:20 p.m. Animal standing up, but very weak and unsteady.

5:25 p.m. Animal recumbent, but quiet, and respiratory effort greatly lessened, being 72 per minute.

May 18—

9:30 a.m. Temperature 100.9. Pulse 70. Respiration 144. Recumbent; made several attempts to arise.

3:00 p.m. Temperature 101.2. Pulse 66. Respiration 60. Animal standing up and eating hay. Recovered.

While this record is more prolonged than the average, it demonstrates the great respiratory distress, prostration, and moderate bloating observed in animals showing well-defined symptoms of poisoning followed either by death or recovery.

After the approximate quantity of the plant required to produce symptoms of poisoning and death had been determined, an attempt was made to find some form of remedial treatment. Animals subjected to treatment were permitted to develop unmistakable signs of incoordination, respiratory distress, and prostration before the treatment was started. The animals were previously fed the fresh larkspur plant in doses large enough to produce definite symptoms of poisoning or death.

Animals Nos. 3888 and 3889 were used for experimental remedial treatment.

Case I

Animal No. 3888 was fed 16 pounds of the whole plant at 4:30 p. m. May 18, 1922.

At 6 a. m., May 19, this animal was down and not able to arise. Symptoms of shallow rapid respiration, bloating, and great distress were especially well defined. The animal was permitted to remain undisturbed until 2:40 p. m. the same day when remedial treatment was instituted. The animal was then in distress and not manifesting any improvement in the condition observed during the early part of the day. One grain of arecolin hydrobromide and one-fourth grain of atropine were given subcutaneously. This was followed almost immediately by profuse salivation, which continued for 15 minutes and ceased entirely after an interval of 30 minutes.

2:45–2:50 p.m. Increased eructation of gas from the rumen occurred followed by marked increase of intestinal peristalsis and reduction of gas distention of the rumen. During this time the tail was elevated as in normal defecation. Slight tremor of gluteal and cervical muscle groups was observed.

3:00 p.m. Temperature 102.6. Pulse 90. Respiration 26.

3:10 p.m. The general distress of the animal was greatly relieved. Respiration becoming deeper and stertor became gradually less during the following half hour; and there were periods when the animal breathed normally.

4:00 p.m. There was a general cessation of distress; and the action of the alkaloids injected subcutaneously gradually subsided. The eructation of gas from the rumen continued, but less frequently than during first half hour after injection of alkaloids. Cognizance

was taken of flies, and the sensorium was greatly improved Salivation returned, but was slight in amount and of short duration. Temperature 101. Pulse 80. Respiration 20.

5:00 p.m. Animal still recumbent but in no apparent distress.

May 20—

8:00 a.m. Animal standing up but weak. Passed several small amounts of feces during the night. During the morning this animal was turned out into the corral with other steers; but it partook of very little food or water during the remainder of the day.

May 21—

Completely recovered.

Case II

Animal No. 3889 was fed 16 pounds of the whole plant at 3 p. m. on May 9, 1922.

May 20—

8:00 a.m. Recumbent and unable to arise, stertorous respiration, gastric tympany, and general depression. Temperature 101. Pulse 70. Respiration 90.

11:45 a.m. Given one-half grain of arecoline hydrobromide and one-eighth grain of atropine sulphate. Animal lying stretched out on its right side and very depressed.

12:45 p.m. Alkaloid injection did not salivate the animal. The position had been changed during the preceding hour to a sternal position, and the general appearance was more animated. Refused to arise.

1:00 p.m. Same dose of alkaloids repeated.

1:10 p.m. The animal arose of its own accord, walked a short distance, and remained on its feet.

1:25 p.m. Eating hay. At 5 p.m. appeared entirely recovered.

The treatment of these two animals is insufficient evidence to warrant a positive conclusion regarding the efficacy of such a line of treatment. Other vegetable alkaloids may give equally good results.

Post-Mortem Lesions.

Detailed post-mortem examination of animals dead as result of partaking of lethal doses of larkspur (*Delphinium andersoni*) did not demonstrate specific lesions which would be positively diagnostic of larkspur poisoning.

Dead animals presented an external appearance of marked bloating with cyanosis of the visible mucous membranes and areas of the skin thinly covered by hair, particularly the inguinal and perineal regions.

The subcutis manifested a decided peripheral venous engorgement.

Focal areas of submucous hemorrhage and congestion were found in both the small intestine and cæcum. Small scattered petechial hemorrhages were noted on the diaphragm and epicardium. The lungs exhibited well-marked passive congestion.

Death resulted from failure of respiration.

The post-mortem lesions alone can be interpreted as being due to a rapidly overwhelming toxemia closely resembling those observed in animals dead from other causes.

Diagnosis.

A positive diagnosis of larkspur poisoning should be made only when animals have been known to graze on larkspur areas and when they exhibit the clinical and post-mortem conditions described above.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 106 RENO, NEVADA September, 1924

FATTENING LAMBS WITH BARLEY AND ALFALFA

By

C. E. FLEMING
Of the Department of Range Management

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

171

NEVADA AGRICULTURAL EXPERIMENT STATION

FATTENING LAMBS WITH BARLEY AND ALFALFA

Every year in Nevada many flocks of immature range lambs are fattened in the feed-lot. Many of these flocks are fed a finishing ration of alfalfa and barley. It is the object of this bulletin to give information concerning the gains in weight and the financial returns that may be expected from the feeding of alfalfa with barley in varying amounts to lambs. The facts presented were obtained through feeding trials made at the Nevada Station and from records kept at lamb-feeding corrals located in various parts of the State.

FEEDING TRIALS AT THE NEVADA STATION

Rations Used.

The feeding rations used at the Nevada Station included (1) alfalfa as the entire ration, and (2) alfalfa fed with barley in quantities of one-fourth pound, one-half, three-fourths, and one pound daily.

Lambs Fed.

The lambs used in the feeding tests at the Nevada Station were grade Corriedales. They were all sired by closely related pure-bred Corriedale rams. Ninety-eight of the ewes which produced the lambs were of closely related cross-bred Corriedale and Rambouillet breeding with ten ewes showing the Hampshire and Dorset breed characteristics. On account of the fairly uniform breeding of the lambs it could be expected that they would respond more evenly to a fixed feeding ration than would lambs of mixed or promiscuous breeding.

Weighing and Feeding.

The lambs were held in corrals without water or feed from 8 a. m. until 2 p. m. before the first weights and the final weights were taken.

They were fed twice daily—8 a. m. and 4 p. m. Water and salt were before them at all times. Twice a day the uneaten hay was removed and a fresh supply was given. The alfalfa fed was second crop, exceptionally fine and leafy. The lambs were fed in combination hay-and-grain racks, located in corrals which adjoined an open shed.

Results of Feeding Trials.

The following table summarizes the feeding tests which were made during the winter months of 1920, 1921, and 1922. These feeding trials have been averaged and presented as one feeding test.

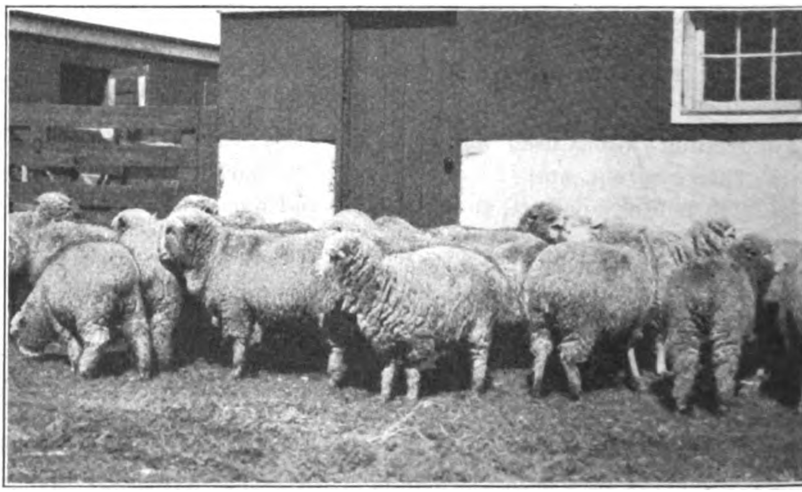


Fig. 1. Lambs Fed Alfalfa Only. They made an average daily gain of .175. To make 100 pounds gain they consumed 1742.8 pounds of alfalfa.

Summary of 70-day Lamb-Feeding Tests, 1920-1922

Rations Fed Daily	Lot 1 Alfalfa	Lot 2 Alfalfa Barley 1 lb.	Lot 3 Alfalfa Barley ¾ lb.	Lot 4 Alfalfa Barley ½ lb.	Lot 5 Alfalfa Barley ¼ lb.
Number of Lambs per lot	25	25	25	25	25
Average initial weight per head	53.00	52.50	53.50	54.00	52.00
Average final weight per head	65.25	74.00	72.50	70.50	66.50
Average total gain per head	12.25	21.50	19.00	16.50	14.50
Average daily gain per head	.175	.307	.271	.235	.207
Average daily ration (lbs. per head)—					
Alfalfa offered	3.56	2.55	2.98	3.03	3.27
Alfalfa consumed	3.05	1.95	2.23	2.44	2.69
Barley		1.00	.75	.50	.25
Feed required per cwt. gain—					
Alfalfa offered	2034.2	830.2	1097.8	1285.4	1578.6
Alfalfa consumed	1742.8	634.8	821.5	1035.1	1298.6
Barley		325.5	276.3	212.1	120.6
Feed cost per cwt. gain—					
*Alfalfa offered	$10.17	$4.15	$5.48	$6.42	$7.89
Alfalfa consumed	8.71	3.17	4.10	5.17	6.49
*Barley		4.88	4.14	3.18	1.80
Total for feed offered	$10.17	$9.03	$9.62	$9.60	$9.69
Appraised value per cwt	$10.50	$12.00	$12.00	$11.50	$11.20
Difference between feed cost and sale value per cwt. basis feed offered	$0.33	$2.97	$2.38	$1.90	$1.51

*Alfalfa $10 per ton. Barley $30 per ton.

The foregoing table shows:

(1) That the poorest and least profitable gain was made with alfalfa as the entire ration.

(2) That the most profitable gain was made with alfalfa and 1 pound of barley daily.

(3) That a satisfactory and profitable gain was made with alfalfa and ¾ pound of barley per head per day.

(4) That to make 100 pounds of gain it required with

(a) Alfalfa alone—

34% more alfalfa than with alfalfa and barley ¼ pound.

68% more alfalfa than with alfalfa and barley ½ pound.

112% more alfalfa than with alfalfa and barley ¾ pound.

174% more alfalfa than with alfalfa and barley 1 pound.

(b) Alfalfa and barley ¼ pound—

27% more alfalfa and 43% less grain than with alfalfa and barley ½ pound.

58% more alfalfa and 56% less grain than with alfalfa and barley ¾ pound.

104% more alfalfa and 62% less grain than with alfalfa and barley 1 pound.

(c) Alfalfa and barley ½ pound—

26% more alfalfa and 23% less grain than with alfalfa and barley ¾ pound.

63% more alfalfa and 34% less grain than with alfalfa and barley 1 pound.

(d) Alfalfa and barley ¾ pound—

29% more alfalfa and 15% less grain than with alfalfa and barley 1 pound.

(5) That to produce 100 pounds gain with alfalfa at $10 per ton and barley $30 per ton it cost for feed alone—

(a) With alfalfa	$10.17
(b) With alfalfa and barley ¼ pound	9.69
(c) With alfalfa and barley ½ pound	9.60
(d) With alfalfa and barley ¾ pound	9.62
(e) With alfalfa and barley 1 pound	9.03

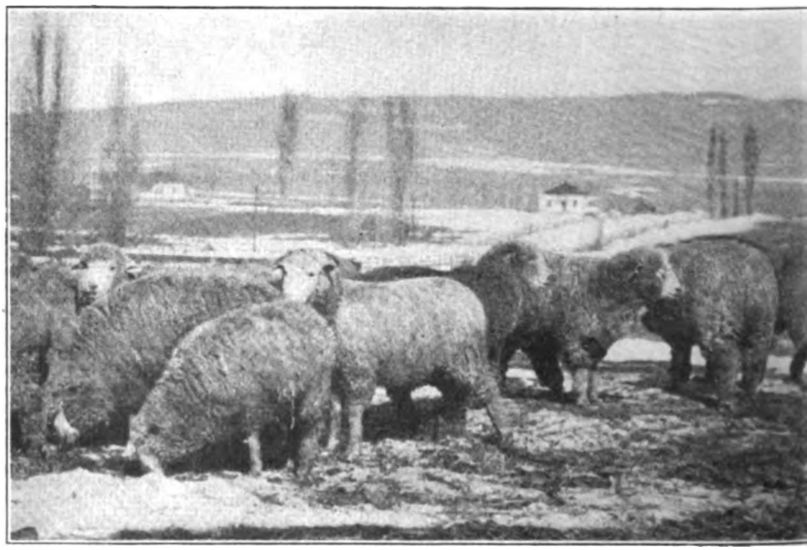


Fig. 2. Lambs Fed Alfalfa and Barley One-Fourth Pound Daily. They made an average daily gain of .207 and consumed 1298.6 pounds of alfalfa and 120.6 pounds of barley for each 100 pounds gain.

(6) That 100 pounds of gain made was worth—

(a) With alfalfa	$10.50
(b) With alfalfa and barley ¼ pound	11.20
(c) With alfalfa and barley ½ pound	11.50
(d) With alfalfa and barley ¾ pound	12.00
(e) With alfalfa and barley 1 pound	12.00

(7) That the difference in the feed cost per 100 pounds gain and the selling value of the 100 pounds gain made was—

(a) With alfalfa	$0.33
(b) With alfalfa and barley ¼ pound	1.51
(c) With alfalfa and barley ½ pound	1.90
(d) With alfalfa and barley ¾ pound	2.38
(e) With alfalfa and barley 1 pound	2.97

(8) That 1 pound of barley for fattening purposes was worth 3.4 pounds of alfalfa.

(9) That with the two lots of lambs receiving alfalfa and barley 1 pound and ¾ pound respectively it took as an average 964 pounds of alfalfa and 300.9 pounds of barley—on the basis of feed offered—to produce 100 pounds of gain. These two lots of lambs were quite equal in the degree of finish.

(10) That with the two lots of lambs receiving alfalfa and barley ½ and ¼ pound respectively it required as an average 1,432 pounds of alfalfa and 166.3 pounds of barley offered to put on 100 pounds of gain.

The following figures were secured from selected commercial lamb-feeding corrals on Nevada ranches:

Summary of Four Lamb-Feeding Operations Involving 11,203 Lambs

	Lot 1	Lot 2	Lot 3	Lot 4
Number of Lambs	5586	483	3234	1900
Number of days on feed	84.2	72.0	47.0	90.0
Average initial weight per head (pounds)	60.8	58.3	74.0	65.0
Average final weight per head	83.8	80.55	87.0	85.0
Average total gain per head	23.0	22.25	13.0	20.0
Average daily gain per head	.273	.309	.276	.222
Alfalfa fed per day per head	2.50	2.30	4.0	2.50
Barley fed per day per head	.738	1.0	.20	.52
Feed used per 100 pounds gain—				
Alfalfa	915.20	744.26	1446.15	1125.00
Barley	270.17	323.59	72.30	234.80
Feed cost per 100 pounds gain—				
Alfalfa	$4.57	$3.72	$7.23	$6.75
Barley	5.40	6.47	1.30	3.74
Total	$9.97	$10.19	$8.53	$10.49
Financial Statement per Lamb—				
Barley	$1.24	$1.44	$0.169	$0.748
Alfalfa	1.05	.828	.94	1.35
Purchase price per head	3.04	2.91	7.77	5.85
Labor cost per head	.152	.165	.176	.40
Investment interest per head	.06	.058	.103	.117
Investment interest per head grain fed	.024	.022	.001	.001
Investment interest per head alfalfa fed	.02	.013	.012	.026
Loss per head from death	.096	.072	.082	.073
Total cost per head	$5.68	$5.50	$9.25	$8.56
Selling price per Lamb	6.57	6.44	9.78	9.35
Net profit per head for all Lambs purchased.	$0.89	$0.94	$0.53	$0.79

Lot 1—Alfalfa $10 per ton, barley $40 per ton.
Lot 2—Alfalfa $10 per ton, barley $40 per ton.
Lot 3—Alfalfa $10 per ton, barley $36 per ton.
Lot 4—Alfalfa $12 per ton, barley $32 per ton.

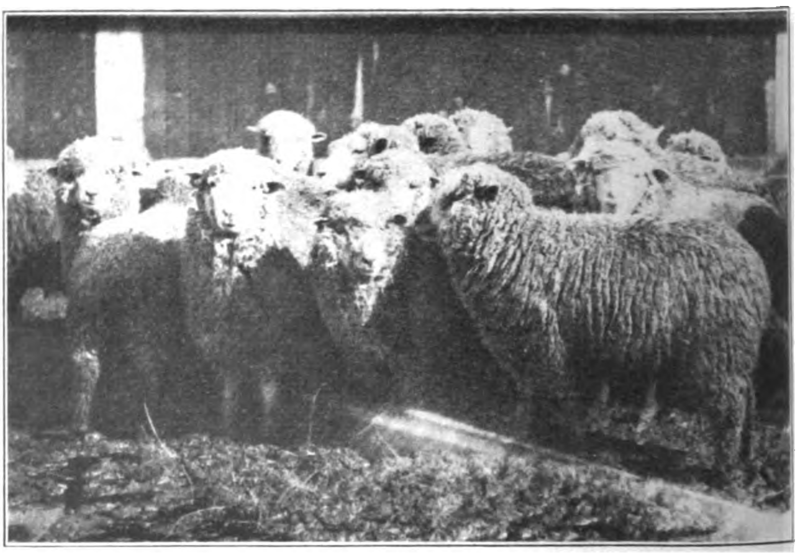


Fig. 3. Lambs Fed Alfalfa and Barley One-Half Pound Daily. They made an average daily gain of .235. To make 100 pounds gain they consumed 1035.1 pounds of alfalfa and 212.1 pounds of barley.

The object of presenting the above figures is not so much to show the daily gains that may be expected from a given ration as to show the profit that may be realized per lamb in Nevada under quite favorable buying and selling conditions when all cost items are considered.

More particularly the above figures show:

(1) That Lots 1, 2, and 5 fed on a commercial scale correspond very closely in daily gains and the amount of feed required to produce one hundred pounds of gain with the three lots of experimental lambs on the Station Farm receiving similar rations, alfalfa with one pound of barley, three-quarters of a pound, and one-half pound of barley per head daily.

(2) Lot 3 made a much higher gain than could ordinarily be expected from such a limited amount of barley fed daily, namely one-fifth of a pound a day. However, the lambs in this lot were fed exceptionally leafy alfalfa in a daily amount which would permit them to select to a very large degree the most nutritious portions of the plants. The refused alfalfa was removed daily, and, further, several times each day the alfalfa was turned over, permitting the lambs to make a greater selection of the most palatable and nutritious parts of the plant. This lot shows that when a feeder has an abundance of fine stemmed leafy alfalfa and only a limited amount of grain, a profitable use may be made of the alfalfa by methods of feeding that will induce the lambs to eat more than the customary amount of the most nutritious parts of the alfalfa—the leaves and flower stems. The refused portions may profitably be fed to stock cattle and horses, thus keeping all waste down to a minimum.

(3) That Lot 1 fed 2.50 pounds of alfalfa and .738 of a pound of barley daily and which were purchased at $5 per cwt. and which sold for $7.85 per cwt. at the corrals, a gain of $2.85 per cwt., made a net profit of 89 cents per lamb.

(4) That Lot 2 fed 2.30 pounds of alfalfa and one pound of barley daily, which were purchased at $5 per cwt. and sold at the corrals for $8 per cwt. with a gain of $3 per cwt., made a net profit of 94 cents per head.

(5) That Lot 3 fed 4 pounds of alfalfa and .20 of a pound of barley daily, purchased at $10.50 per cwt. and sold at the corrals for $11.25 per cwt., a gain of 75 cents per cwt., made a net profit of 53 cents per head. The margin here between the cost price and the selling price per cwt. is low, but offset by a comparatively cheap feeding ration.

(6) That Lot 4 for 2.50 pounds of alfalfa and .52 of a pound of barley per head daily and which were purchased for $9 per cwt, and sold at the corrals for $11 per cwt., a gain of $2 per cwt., made a net profit of 79 cents per head.

(7) That with the prices which usually prevail in this State for alfalfa and barley it is not profitable to feed immature range lambs for gain in weight alone. Ordinarily, to make a profit there must be an advance in the selling price per hundred weight over the purchase cost per hundred weight.

This advance in the selling price is usually brought about by two factors: (1) that the finished lamb is usually worth from 50 cents to

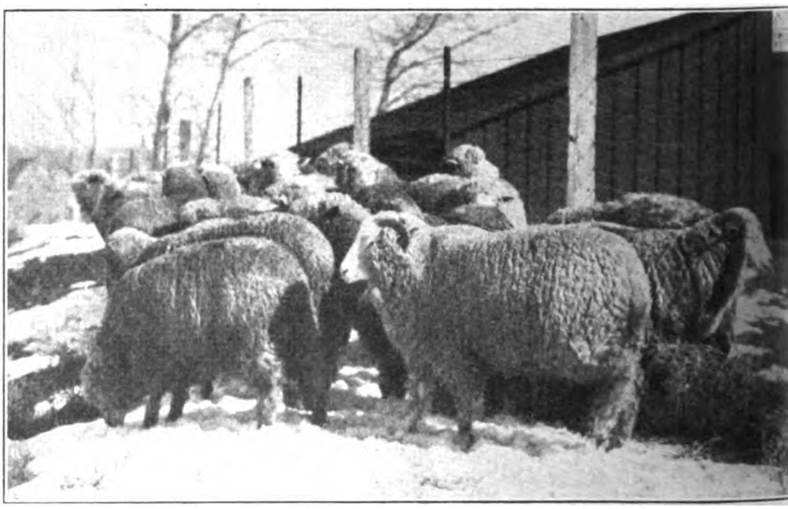


Fig. 4. Lambs Fed Alfalfa and Barley Three-Fourths Pound Daily. They made an average daily gain of .271. To make 100 pounds gain they consumed 821.5 pounds of alfalfa and 276.3 pounds of barley.

Fig. 5. Lambs Fed Alfalfa and Barley One Pound Daily. They made an average gain of .307. To make 100 pounds of gain they consumed 634.8 pounds of alfalfa and 325.5 pounds of barley.

$1.50 more per cwt. than the feeder lamb, and (2) due to supply and demand there is normally a monthly increase of about 40 cents in the value of lambs from November to March. These two factors are vital to the lamb feeder; for the increase in value by monthly periods, together with a better price for the fat lambs over the feeder lambs, determines to a large extent the profit any particular lamb-feeding operation will yield.

Variations in Daily Gains of Lambs Fed Same Ration.

There is a very marked difference in the total gains for a given period which lambs will make on the same ration. Out of 120 lambs on feed for 90 days the variation between 20 lambs making the highest total gain and 20 making the lowest total gain for the period was 9.75. The variation in the daily gains of lambs on the same ration, aside from going off feed, etc., can usually be attributed to one or more of the following causes:

(1) Lambs may become stunted early in life because of losing their "mother tallow" due to an insufficient milk supply and dry feed.

(2) Lambs may become stunted because of dry feed during mid- and late summer.

(3) Lambs sired by inferior rams may lack the inborn tendency to develop rapidly to a desirable conformation and to make the most economical use of a given ration.

(4) Lambs may become stunted because range conditions force them to drink water containing a high percentage of alkaline salts.

(5) Lambs often fail to develop properly because they are forced to graze on forage plants not really poisonous but highly injurious. Such plants as certain species of awned grasses, the awns of which become lodged in the organs of the head, interfering with proper eating, rumination, etc., and certain species of shad scales (*Atriplex*) which cause destructive bodily action when grazed in large quantities.

(6) Lambs may become infested with stomach worms or other parasites which cause derangement of the bodily organs.

In a flock of lambs all from the same ewe band a general comparison of the relative numbers of well-developed thrifty lambs and of undeveloped unthrifty lambs will give a good index to the uniformity of gain that the flock can be expected to make.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 107 RENO, NEVADA NOVEMBER, 1924

THE METROPOLIS RECLAMATION PROJECT

A Survey of Farm, Home, and Social Conditions Upon a Project Still in an Early State of Development

By

J. CARLOS LAMBERT,
Formerly County Agent Agricultural Extension Division

PUBLISHED BY THE UNIVERSITY OF NEVADA,
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
1925

1[39]

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF REGENTS

OFFICERS

STAFF

FOREWORD

The future agricultural progress of Nevada will depend upon the successful development of new irrigation projects based upon the storage of water now running to waste in winter and spring, and perhaps quite as much upon the subdivision and colonization of certain large ranches with recognized water rights and favorably located with reference to markets and transportation.

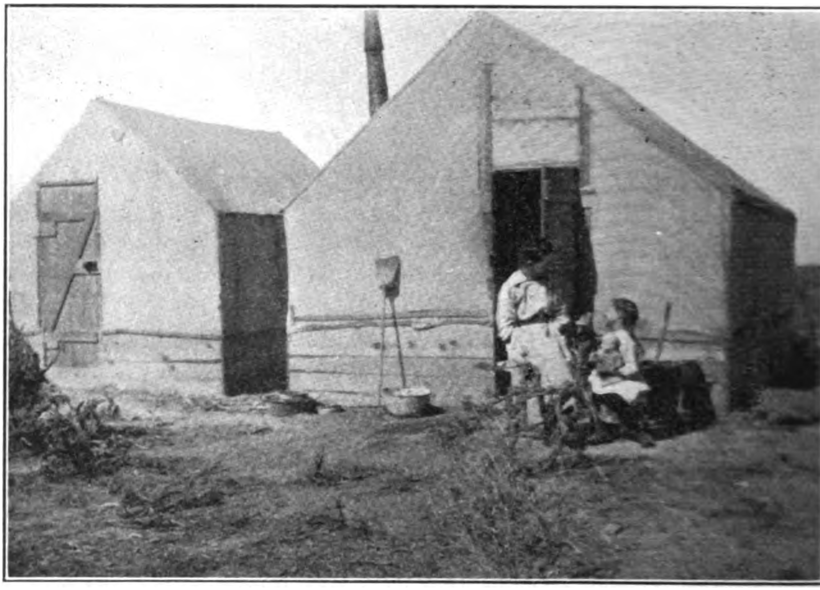
In the colonization of projects of either type the difficulties are many. Grim natural obstacles must be overcome in the conquest of the desert; markets must be found; and difficult social and financial problems must be solved.

The subject-matter of this bulletin is a study of a typical small reclamation project in Nevada, developed by the courage of the colonists and the foresight of their leaders under conditions not nearly so favorable as those usually considered necessary for success of new projects. To the writer of this bulletin, J. Carlos Lambert, as a representative of the Agricultural Extension Service of the University, we should give a large share of credit for the degree of success actually attained. Perhaps quite as much credit should be given to the social and religious influences thrown around the colonists by the church organization to which most of them belong, and to the encouragement and wise counsel given them by the Southern Pacific Railroad in a praiseworthy effort to develop tonnage and traffic.

The bulletin presents the results of a detailed survey of the present status of the Metropolis project in Elko County, Nevada. It is published in the hope that it may prove of value to students of the problems of reclamation in western America.

S. B. Doten, *Editor.*

University of Nevada, November 1, 1924.



The First Home of the Settler.

Only a Few Years Later.

THE METROPOLIS RECLAMATION PROJECT

INTRODUCTION

Metropolis is located in Elko County in the northeast corner of Nevada. The district lies about seven miles north of the Southern Pacific Railroad and ten miles northwest of Wells, Nevada, a town on the main line of the Southern Pacific. A branch railroad seven miles long connects Metropolis with the main line.

It is a matter of history that the transcontinental railroad was completed in 1869. The portion between Ogden and San Francisco, formerly the Central Pacific, is now part of the Southern Pacific Railway. Ranching began in Elko County when the railroad was under construction, between 1860 and 1869.

The altitude of the Metropolis district is 5,611 feet and the soil of the region is a light clayey loam under which, in places, there are areas of limestone hardpan. A luxuriant growth of sagebrush covers the ground. There are no pebbles or stones and one may plow for miles without striking a rock. There is an abundance of grass, for an arid region, and probably no better cattle range exists in the arid west than upon the hills and mountains to the north.

The average frost-free period is 107 days, from June 2 to September 17. The average annual precipitation is a little less than ten inches.[1]

HISTORY

It was not until 1911 that an attempt was made to reclaim the land included in the Metropolis project. At this time the Pacific Reclamation Company, a corporation composed largely of eastern capitalists, obtained possession of thirty or forty thousand acres of land at the mouth of Emigration Canyon (Now Bishop Creek Canyon) and constructed a dam in the canyon for the purpose of impounding the flood waters of Bishop Creek for use in irrigation. A townsite was laid off and a hotel was built at a cost of one hundred thousand dollars.

The company carried on an extensive advertising campaign all over the intermountain country. They claimed to have water sufficient to irrigate 30,000 acres of land. Many home-seekers and investors came. The hotel was filled, and the homesteaders' "shacks" could be seen in every direction. In addition to the irrigated land the company claimed that many thousands of acres of sagebrush land could profitably be dry farmed.

During 1913 and 1914 the population reached almost 1,000. Soon it became evident that there was not water enough to irrigate anywhere near the 30,000 acres. Dry farming was not a success. Rodent pests and other difficulties incident to pioneering in the west were encountered, with the result that the settlers began to leave.

The land and water were sold for $75 per acre, ten per cent down and the balance in ten annual payments with interest on the deferred payments at the rate of six per cent. Many of the settlers did not have sufficient capital to begin with. The expense of clearing and breaking the land was mounting up, and few farmers were able to get a crop

[1]From report of H. F. Alps, United States Weather Bureau, Reno, Nevada.

before the second year. Food and clothing were needed, and many of the settlers were obliged to leave the land and seek employment.

The state and federal governments saw the sad plight of these settlers and attempted to aid them in every possible way. In 1917 a county agent of the Agricultural Extension Service of the University of Nevada was stationed at Metropolis. Seeing immediately the hopelessness of an attempt to build up a permanent agricultural industry based on grain farming, this agent determined that the dairy industry should be encouraged. At that time there were only three farmers on the project selling dairy products. Later, dairying became the principal industry.

The population has continued to dwindle, even up to the present time (1924). There are now only about 35 families left.

INFLUENCES OF THE MORMON CHURCH

In spite of all the help and encouragement given by the state and federal governments and the Southern Pacific Railroad, the writer firmly believes that all the settlers would have abandoned the project, if the social and religious organization of the church had not given them hope and held them together. A large proportion of the colonists were members of The Church of Latter Day Saints. A ward organization was formed in the early days of the project, and the people came together often for worship and for recreation. These people have great faith in their leaders. They were encouraged to struggle along and not give up; their leaders holding before them a promising and truthful picture of beautiful fields and a prosperous community.

The amusements fostered by the church were many and varied; they served to take the minds of the discouraged farmers off their troubles. There were dances and dramatics and concerts by home talent as well as religious gatherings.

A CONSOLIDATED SCHOOL ESTABLISHED

In 1912, the second year of the project, a $25,000 schoolhouse was built by the county; and both grade and high school instruction was begun. The Metropolis schools have the reputation of being among the most efficient in the State. Practically all the children have continued in school until they finished the high school courses. This school system has been a strong influence in holding the people on the land.

PURPOSE OF THIS STUDY

This study was planned and undertaken for the purpose of securing a careful and thorough analysis of the economic, social, and home conditions governing new irrigation projects in Nevada. The irrigation district at Metropolis, Nevada, is typical of a large group of projects in the intermountain States.

The data which follow were obtained by a survey made by the writer during the months of March, April, and May, 1924. The tables show the condition of the farm business on this project in the year 1923, in a brief and convenient form.

THE SURVEY IN DETAIL

TABLE No. 1
Farms of Less Than 80 Acres

Total farm acreage	Farm-stead	Pasture	Fallow	Alfalfa	Wild hay	Potatoes	Oats	Rye	Sun-flowers	Barley	Wheat	Labor income
38	3			25		3.5					1.5	$296
60	2.5	6	11	9	2	9	1.5				9	772
40	1.5			35		3.5						953
20	1	5		13		1						685
40	3		11	15	1	3					8	1,301
60	3	28				3	6	20				43
23	2			18		3						663
66	6		14	30		6	2.5			5	2.5	295
42.5	5		23			8				6		425
Average: 43.2	3	4.3		18.7	.2	4.4	1.1	2.2	0	1.2	2.3	$432

TABLE No. 2
Farms of 80 to 100 Acres

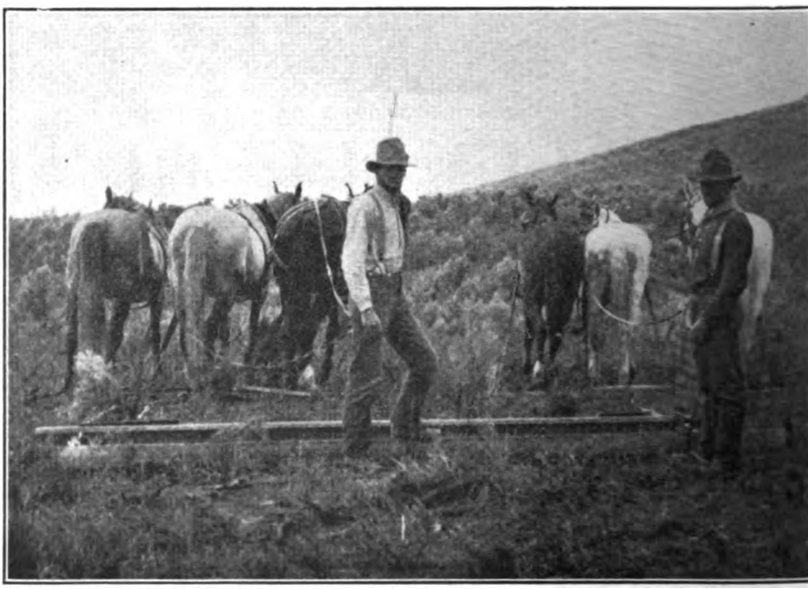
Total farm acreage	Farm-stead	Pasture	Fallow	Alfalfa	Wild hay	Potatoes	Oats	Rye	Sun-flowers	Barley	Wheat	Labor income
80	9	31		12		6	4		3	12		$883
80	5	6	11	17		18	7.5			15		2,334
80	4	3		50		15	3			1	9	605
120	8	50		40	8	2					12	223
100	6	30		30		12	10			6	6	49
80	5	10		22	30	10					3	628
80	5	10	7	40		6	7			5		1,477
105	5			40		12			3	4	6	1,341
Average: 102.6	6	17.5	2.2	31.3	4.7	10.1	3.9	0	.75	5.3	4.5	$908

TABLE No. 3
Farms of 160 to 320 Acres

Total farm acreage	Farm-stead	Pasture	Fallow	Alfalfa	Wild hay	Potatoes	Oats	Rye	Sun-flowers	Barley	Wheat	Labor income
225	4			16		6	3				9	$272
228	10	145		60		8				.5	3	911
200	4	131		50		10					5	434
160	7	78		25		6					4	1,128
200	10	44		35		6		100	2		3	665
230	20	80		10	120							622
240	8	56			30	6		140				472
240	10	100	63	30	20	1		15			1	49
Average: 215.3	9	79.2	8	28.2	21.2	5.3	.3	32	.2	.6	3.1	$615

TABLE No. 4
Farms of More Than 320 Acres

Total farm acreage	Farmstead	Pasture	Fallow	Alfalfa	Wild hay	Potatoes	Oats	Rye	Sunflowers	Barley	Wheat	Labor income
400	10	304	30	40	------	6	------	------	------	10	------	$1,495
480	6	374	------	50	------	7	------	40	3	------	------	783
342	10	265	------	40	------	2	------	------	------	------	25	676
440	10	354	------	20	10	16	25	------	------	------	5	2,444
430	5	363	------	60	3	------	------	------	------	------	2	1,463
440	10	184	------	80	150	8	5	------	2	------	3	595
Average: 422	8.5	307	------	48.3	27.1	6.5	5	6.6	.8	1.6	5.8	$1,242



Railing the Sage—Sagebrush land is commonly cleared by dragging it with a steel rail.

THE CROPS WHICH ARE GROWN AT METROPOLIS

All the crops that may be grown in any of our intermountain valleys at this altitude are raised at Metropolis. However, the principal commercial crops are alfalfa (two cuttings), wild hay on the wet lands, small grains, potatoes, sunflowers (for silage), and rye grown for hay and grain on dry land which cannot be irrigated.

The grains, wheat, oats, barley, rye, and hog millet, do not yield heavily; and continuous planting to one crop soon depletes the soil. It has been noticed many times on this project that if a field where grain had been raised for several years is summer-tilled and permitted to lie idle for a year, then in the following year a heavy crop of grain or potatoes will be secured. This is not due to the fact, as many suppose, that two years' moisture has been conserved for one year's crop;

for this is not the case, as the greater part of the moisture actually escapes. A more probable explanation may be found in the fact that the summer tillage favors the growth of bacteria in the soil and these bacteria help to make plant food available which has not before been set free.

As a rule alfalfa produces two good cuttings per year. The third crop quite often grows high enough to be of considerable value for fall pasture. This, of course, depends upon the extent of the water supply. Sometimes the late summer and early fall are unusually dry. There is then a scarcity of water for irrigation, and there is no third crop for pasture.

All kinds of vegetables can be raised in the soils of the Metropolis

Raking the Sage—This is the second step in getting rid of the native vegetation.

project. Potatoes, mangels, sugar beets, cabbage, and cauliflower grow exceptionally well.

A study of the four tables already presented will show that with a single exception the labor income increases with an increase of acreage. But a study of acreage alone is not a true indicator of the size and extent of the farm business. Other factors must be considered, such as the kind of crops grown, the number of live stock carried, the amount of work done by horses and men, and the capital employed.

One notices that there is an increase in alfalfa and wild hay acreage with the increase in the size of the farms, and a decrease in the grain acreage as the size of the farm increases. This is in line with the experience of the community that the growing of grain beyond that needed for home consumption is not profitable and should be abandoned, and a greater acreage devoted to forage crops, hay and silage.

NUMBER AND KIND OF LIVE STOCK

Nevada is, agriculturally speaking, a livestock state. Nearly all of her live stock are range cattle and sheep. The community under discussion is not a typical Nevada community from the standpoint of the type of farming. Many of the farmers on this project, when they began farming a few years ago, had no stock at all, and others had two or three cows, besides a team and a few chickens. When dry farming and grain raising on irrigated land failed to return profits these farmers turned to live stock, principally dairy cows.

In tables five, six, and seven, the farms are classified with reference to the number of dairy cows carried and milked. It is noted that with few exceptions the number of other live stock increases with the number of dairy cows; and the total number of animals increases in direct proportion to the total number of dairy cows. The large average labor income for farmers in the group having from nine to twelve dairy cows is accounted for in part by the fact that two of these farmers are school teachers, and as a result their labor incomes are large.

TABLE No. 5
Farms Having Eight or Less Dairy Cows

Farm number	Total acreage	Cows	Heifers	Horses	Beef cattle	Bulls	Hogs	Sheep	Poultry	Total animal units	Labor income
1	80	8	8	6	-----	1	4	16	25	22	$883
8	228	8	6	5	-----	-----	3	-----	90	15	911
7	38	4	6	5	-----	-----	4	-----	40	13	396
10	120	6	5	6	-----	-----	5	-----	40	16	-223
11	100	8	4	11	-----	-----	6	-----	20	22	49
12	60	5	4	8	-----	-----	-----	-----	21	15	-772
13	40	5	5	5	-----	-----	2	-----	40	13	953
15	342	6	3	11	-----	-----	-----	125	160	39	676
16	80	8	10	11	-----	-----	5	-----	100	26	628
18	40	7	1	5	-----	-----	2	-----	60	13	1,301
20	240	7	4	9	-----	1	3	-----	80	20	472
19	80	6	3	4	-----	-----	2	-----	40	14	1,477
25	105	8	1	5	2	-----	10	-----	25	15	1,341
26	66	7	5	5	-----	-----	1	-----	3	15	295
30	42	5	5	3	-----	-----	2	-----	35	11	425
Average	110	6.5	5.3	6.6	.13	.13	3.2	9.4	53.2	18	$594

TABLE No. 6
Farms Having 9 to 12 Dairy Cows

Farm number	Total acreage	Dairy cows	Heifers	Horses	Beef cattle	Bulls	Hogs	Sheep	Poultry	Total animal units	Labor income
2	80	11	2	5	-----	2	4	-----	130	21	$2,334
3	400	12	14	22	-----	-----	1	-----	30	41	1,495
4	225	11	6	6	-----	1	6	-----	30	23	2,727
5	80	10	3	4	-----	1	2	30	24	23	605
6	480	12	11	11	-----	1	3	-----	40	31	783
14	20	9	5	3	-----	-----	3	-----	35	16	685
17	440	12	-----	13	20	-----	-----	-----	225	47	2,444
22	60	9	6	10	-----	-----	4	-----	22	23	43
23	160	9	9	6	-----	-----	10	-----	40	22	1,128
24	23	10	5	9	-----	-----	2	-----	25	22	663
27	200	11	9	5	-----	1	2	-----	3	22	665
Average	194.3	10.6	6.3	8.5	1.8	.54	3.4	2.7	55	26.4	$815

TABLE No. 7
Farms Having More Than 12 Cows

Farm number	Total acreage	Dairy cows	Heifers	Horses	Beef cattle	Bulls	Hogs	Sheep	Poultry	Total animal units	Labor income
9	200	15	10	5	......	1	2	......	60	27	$434
21	240	21	9	20	34	......	6	......	110	82	423
28	430	15	13	11	......	1	5	......	95	35	1,463
29	440	25	10	15	100	......	10	......	80	148	595
31	230	17	13	8	30	1	5	......	40	33	622
Average	308	18.6	11	12.8	3.3	.6	5.6	......	77	65	$703

SOURCES OF CASH INCOME

Table No. 8 shows the various sources of the farm cash income. It is noted that potatoes are the chief source of revenue from field crops. All the farmers grow potatoes, mostly the Netted Gem variety, and ship them to the California market.

Practically all the grain and hay grown are fed to stock and are not sources of much direct income.

TABLE No. 8
Sources of Cash Income

Farm No.	Potatoes	Hay	Wheat	Oats	Barley	Cream sold	Live stock sold	Eggs	Wool	Miscellaneous	Total cash income
1	$83.00					$600	$146			$1,060.00	$1,889.00
2	520.00					937	258	$66.00	$60.00	1,705.00	3,446.00
3	376.00					1,161	525			413.00	2,475.00
4	116.00			$75.00		582	218			464.00	1,455.00
5	418.00		$30.00	30.00		685	22	70.00		41.00	1,296.00
6	221.00	$40.00				800	335	43.00	132.00	187.00	1,758.00
7	212.00	410.00				326	59		86.00	339.00	1,432.00
8	250.00		52.00	45.00		1,150	340	118.00		112.00	2,067.00
9	270.00					598	106	13.00		140.00	1,127.00
10	50.00		175.00			240	105			300.00	870.00
11	480.00					574	36			667.00	1,757.00
12	300.00					35		4.00		484.00	823.00
13	200.00					291	18			645.00	1,163.00
14	60.00					590	15	12.00		392.00	1,069.00
15	100.00					60	318	319.00	318.00	625.00	1,740.00
16	450.00	210.00				203	343	190.00		34.00	1,430.00
17	950.00			400.00		400		700.00		1,600.00	4,050.00
18	360.00					199	198	103.00		728.00	1,390.00
19	118.00			300.00		640	60	20.00		505.00	1,643.00
20	296.00					305	166	81.00		353.00	1,201.00
21	36.00	154.00				1,200	1,720	200.00		513.00	3,823.00
22	240.00					380	439	20.00		370.00	1,449.00
23	251.00		45.00			480	244	25.00		153.00	1,198.00
24	55.00					430	144			368.00	997.00
25	370.00					720	154			700.00	1,914.00
26	148.00		196.00		$54	334	91			51.00	874.00
27	333.00					640	41	45.00		40.00	1,099.00
28	300.00					1,006	318	206.00	127.00	205.00	2,162.00
29	936.00	1,000.00				1,200	3,825	125.00		50.00	7,136.00
30	236.00		180.00			242	8	50.00		454.00	1,170.00
31						1,000	1,162		350.00		
Average	$281.70	$58.50	$21.80	$27.40	$1.70	$580	$368	$77.60	$34.60	$441.80	$1,804.20

Cream and live stock are two principal sources of income. The sale of cream is undoubtedly the most important source of profit for these farmers. The cream is sent to the Centralized Creameries located in Elko, Nevada, 50 miles distant, and to Reno, Nevada, 350 miles away.

The price received per pound for the butter fat last year was from five to eight cents higher than the price paid for butter fat by the Utah creameries. In August of last year these farmers were receiving fifty cents per pound for the fat delivered at the creamery. At that time the condensers in Cache Valley were paying the same price to the farmers for butter fat in the milk delivered at the factory. The price of butter fat in the same cream averaged fifty cents for the entire year.

A glance at table eight will show that eggs are an important source of income. No doubt the farmers in this locality could very profitably increase their poultry flocks.

The figures under Miscellaneous Receipts in table eight are unusually large compared with the receipts which farmers living in other localities receive from miscellaneous sources, so that table nine is included for purposes of clarification.

TABLE No. 9

Sources of Miscellaneous Income

Farm number	Manual labor	Team work	Premiums	Teaching school	County agent	Pasturage
1		$500.00		$560.00		
2		5.00	$300.00	1,400.00	$1,000.00	
3	$348.00		65.00			
4	40.00	400.00	24.00			
5	25.00		16.00			
6	152.00		35.00			
7	300.00	25.00	14.00			
8	12.00	50.00	50.00			
9	121.00		19.00			
10	300.00					
11	667.00					
12	450.00		34.00			
13	100.00		15.00	530.00		
14	392.00					
15	625.00					
16	2.00	32.00				
17				1,600.00		
18	722.00		5.00			
19	500.00		5.00			
20	341.00					$12.00
21	500.00		10.00			3.00
22		370.00				
23		153.00				
24		170.00				
25	100.00					
26	50.00		1.00			
27	25.00	15.00				
28	125.00		10.00			
29			50.00			
30	350.00	96.00	8.00			

ANALYSIS OF THE BUSINESS

Tables A, B, C, and D, which follow are an attempt to analyze the farm business from the standpoint of size of farm, farm balance, production, labor and capital.

PRODUCTIVE WORK UNITS

A productive man-work unit is the amount of work necessary to grow and harvest one acre of hay, one cutting. On an average it requires ten hours to do a unit of work.

All kinds of farm labor have been reduced to units.[2] The thirty-one farmers under consideration averaged 343 productive work units per farm. This number is considerably above the average in the United

[2]Warren's "Farm Management," pp. 350–354.

States. A productive horse-work unit is the amount of horse work required to grow and harvest one acre of hay, one cutting. The average for these farms was 68.1 productive horse-work units per work animal. The productive work-units per man were also above the average. They were 372.3 per man.

The crop-acres handled per man were 63.8 acres, and there were ten acres of crops harvested per work horse.

In table D the average value of the real estate on each farm is given and the average of these averages is also figured out. The facts seem to show that on this project good plow land with water is worth around $100 per acre, meadow land about $50 per acre, and sage land about $5 per acre.[3] The per cent of total area in crops averages 56.4%. The value of the barns per crop-acre amounts to $3.51 and the value of machinery per crop-acre equals $10.27. There were 9.88 dairy cows per farm and 19 other important stocks. The man equivalent per farm amounted to 1.2.

TABLE A

Size of Farm Business

Farm number	Product man-work units	Acres of crops	Acres pastured	Animal units	Man equivalent	Capital	Labor income	No. of cows
1	264.3	40	8	5	2.8	$10,247.00	$883.00	7.5
2	511.5	58	6	10	1.0	12,605.00	2,334.00	10.5
3	305.2	41	180	10	1.5	7,720.00	1,495.00	10.5
4	384	56	304	23	1.0	22,921.00	272.00	12.5
5	414.4	73	----------	5	1.67	10,162.00	605.00	9.5
6	489	100	374	52	1.37	8,745.00	783.00	12.0
7	208.2	37	7.5	.6	----------	6,085.00	296.00	6.0
8	478	75	142	14	1.25	5,530.00	911.00	8.0
9	467.5	65	55	15	1.4	10,222.00	434.00	14.5
10	233	62	50	8	6.6	5,728.00	-272.00	5.5
11	224.2	64	30	15	.5	10,436.00	49.00	7.5
12	225.6	31.5	15	9	.8	4,382.00	-772.00	5.0
13	201	38.5	----------	7	.6	5,153.00	958.00	5.0
14	160	14	5	.5	.5	2,393.00	685.00	8.5
15	330.5	67	265	6	1.0	6,959.00	676.00	5.5
16	330.5	65	10	20	1.3	8,253.00	628.00	.8
17	370	76	54	26	1.3	12,262.00	2,444.00	12.0
18	181.2	26	6.5	8	.42	5,207.00	1,301.00	
19	266.5	58	10	7	.75	5,705.00	1,477.00	10.0
20	500	176	56	11	.6	9,573.00	472.00	7.0
23	236.7	29	28	11	.8	7,957.00	423.00	9.0
22	----------	75	----------	10	.75	8,300.00	43.00	8.5
21	513.7	47	100	33	1.5	25,455.00	1,128.00	21.0
24	240.2	21	----------	13	.6	2,425.00	663.00	10.0
25	365.5	65	25	6	.5	5,403.00	1,341.00	8.0
26	250.5	46	----------	7.5	.9	6,633.00	295.00	6.5
27	525.2	146	46	10	.3	11,809.00	665.00	10.5
28	495	67	363	35	1.0	11,800.00	1,463.00	15.0
29	1,018	246	184	120	3.5	36,220.00	595.00	25.0
30	241.6	27.5	----------	7	.9	5,489.00	425.00	5.0
31	559	130	80	68	2.0	16,917.00	622.00	17.0
Average	343	68.6	92.4	19	1.2	$10,016.00	$753.00	9.88

[3]In comparison with the actual selling-prices of similar land in other portions of Nevada, these figures are evidently conservative—Editor.

TABLE B1
Farm Balance

Farm number	Crop acres per animal unit	Pasture acres per animal unit pastured	Crop index
1	2.0	0.7	74
2	2.5	0.4	83
3	1.1	6.2	87
4	1.75	9.0	77
5	4.35		95
6	3.9	12.0	46
7	2.14		121
8	3.0	10.2	68
9	2.4	2.2	68
10	4.2	4.6	156
11	2.8	1.6	65
12	2.2	1.5	97
13	2.8		75
14	0.8	0.4	67
15	9.9	8.8	37
16	2.0		104
17	2.0	10.0	92
18	2.0		102
19	4.1	0.8	95
20	9.8	3.5	36
21	1.0	2.5	166
22	1.23	1.47	54
23	36.5		79
24	0.9		86
25	4.3	2.0	71
26	3.3		53
27	6.5	2.6	46
28	1.1	7.3	83
29	1.7	4.6	122
30	3.0		124
31	1.6	1.0	105
Average	3.5	2.7	85

TABLE B2
Production

Farm number	Yield of important crops per acre						Butter fat sold per cow	Cattle increase and sales per cattle unit
	Potatoes bushels	Alfalfa tons	Wild hay tons	Wheat bushels	Oats bushels	Barley bushels		
1	80	1.0				25	$80.00	$30.00
2	90	2.0					58.00	24.00
3	200	2.0				12	93.00	47.00
4	100			13	17		55.00	13.00
5	90						72.00	7.00
6	85	1.0					66.00	16.00
7	103	3.0					43.00	20.00
8	95			48			144.00	10.00
9	83	1.6					41.00	15.00
10		3.0	1.75	33			43.00	34.00
11	200	1.12					79.00	7.00
12	111	1.5		20			7.00	26.00
13	171	1.75					58.00	13.00
14	50	1.5					69.00	7.00
15	100	.8						5.00
16	180	2.0	1.3				25.00	15.00
17	154	1.5	1.0		27		33.00	69.00
18	120	2.3				31	12.00	16.00
19	110	1.5			44	26	106.00	23.00
20	150		.85				43.00	17.00
21		4.0	2.25				57.00	14.48
22	80						42.00	24.00
23	175	2.5		30	10		56.00	26.00
24	70	2.25					43.00	6.00
25	100	1.5					90.00	4.00
26	100	.66		20			51.00	20.00
27	200	1.5					61.00	16.00
28	150	2.0					66.00	9.00
29	200	3.75	1.0		100		100.00	12.00
30	110	2.5		34			48.00	15.00
31		1.0	1.6				59.00	16.00
Average	156	1.8	1.39	28.2	29.6	23.5	$60.00	$18.02

TABLE C
Labor

Farm number	Productive work units per man	Crop acres per man	Animal units, except work animals, per man	Productive horse work units per work animal	Crop acres per work animal
1	330	50	22.5	59	13.0
2	511	58	37	61.7	11.6
3	384	56	23	1.4	2.5
4	204	27.3	11	28.6	6.8
5	248	49.6	7.7	73.1	18.0
6	357	73	23.4	30.4	9.0
7	364	62	17	26.9	7.4
8	290	58	10	29	8.8
9	334	46.4	16	49.7	13.0
10	353	94	15	31.4	12.2
11	448	128	22.5	21	5.5
12	282	39	11.3	28	6.6
13	335	64	14	23.4	7.7
14	300	28	33	116	4.0
15	330	67	28	32	11.0
16	260	50	13	168	6.0
17	285	58.5	20	19	6.0
18	431	65	15	28	6.5
19	335	.77	1.5	42	13.8
20	833	293	15	58	19.0
21	342	45	31	9.1	3.5
22	296	36	16	13.4	3.8
23	500	100	20	48	13.6
24	400	35	24	9.7	2.3
25	730	130	20	53	13.0
26	268	5.1	10	32.8	9.0
27	404	11	13.1	94.9	29.0
28	495	67	40.2	20	6.4
29	291	70	38	31.8	16.0
30	302	47	9.5	46	10.6
31	280	65	38.7	22.2	16.2
Average	372.3	63.8	19.3	68.1	10.0

TABLE D
Capital

Farm number	Value of real estate per acre	Per cent of total area in crops	Value of barns per animal unit	Value of barns per crop acre	Value of machinery per crop acre
1	$75.00	50	$12.00	$6.25	$62.50
2	100.00	72	----------	9.00	8.62
3	40.00	14	10.00	2.44	8.30
4	22.00	14	10.00	6.00	8.30
5	93.00	91	4.26	6.85	10.27
6	100.00	----------	29.00	4.00	15.00
7	100.00	92	10.00	4.68	11.80
8	86.00	33	9.83	----------	2.44
9	40.00	32	7.00	3.00	3.60
10	33.00	51	6.80	1.61	4.60
11	75.00	64	4.44	1.56	14.86
12	50.00	52	12.44	5.87	17.00
13	100.00	96	----------	----------	5.20
14	57.00	70	----------	----------	12.50
15	13.00	19	----------	----------	4.40
16	72.00	81	3.13	1.53	5.00
17	21.00	17	2.60	1.60	6.25
18	100.00	65	4.00	2.00	16.65
19	50.00	72	3.60	.88	10.33
20	30.00	73	8.32	.85	4.26
21	83.00	27	5.32	5.22	7.50
22	100.00	48	----------	----------	11.20
23	37.00	47	8.53	2.33	0.00
24	86.00	91	2.95	3.32	12.09
25	34.00	62	3.32	.77	9.05
26	83.00	70	----------	----------	4.90
27	48.00	73	4.57	.68	3.25
28	19.00	15	4.14	7.46	4.48
29	56.00	56	10.22	6.10	8.13
30	98.00	88	4.00	1.33	8.16
31	47.00	57	3.95	2.46	8.00
Average	$62.80	56.4	$7.36	$3.51	$10.27

FARM EXPENSES

The expense for hired labor among these farmers is very low. Various reasons may be assigned. First the farmers' families are fairly large, and the older children are able to help out with the farm work, especially during the four summer months. Again, the low prices received for many farm products and the high wages demanded by farm help has been very discouraging to the producer, and as a consequence production has been curtailed.

The expenditures for new buildings and repairs have likewise been low. These expenditures, however, do not fully show the improvements

A Wheat Field on the Metropolis Project.

and repairs which have actually been made. Good second-hand railroad ties can be obtained near at hand for five to ten cents each; and several of the farmers have built very substantial stables and even houses of these ties at a very small outlay of money.

The expense for horse-shoeing is small and the cost of fire insurance premiums amounts to only $3 per farm.

Table 10 below gives a detailed account of all the expenses of the thirty-one farms. Generally speaking, the expenses are low. Taxes are low in comparison with land of the same quality in other parts of Nevada.

TABLE 10A
Farm Expense

Farm number	Day help	Board for day help	Year help	Value of board of year help	Month help	Work and board help of farm	Bags
1	$15.00	$5.00					
2	600.00	25.00				$125.00	
3						370.00	
4	20.00					240.00	
5	91.00	25.00				300.00	
6	25.00	12.00				150.00	
7							
8						250.00	$7.00
9						490.00	
10						400.00	
11						300.00	
12	45.00	5.00			$175.00	90.00	
13	80.00						
14						40.00	
15						300.00	
16	100.00	30.00				125.00	
17						900.00	
18						25.00	20.00
19							
20	50.00						
21	100.00	50.00				560.00	
22							
23						100.00	
24							
25	60.00	14.00				200.00	5.00
26	17.00						
27	170.00	20.00					
28						175.00	
29			$720.00	$180.00	480.00	750.00	
30	47.00	10.00				300.00	7.00
31	100.00					800.00	
Average	$49.00	$6.00	$23.00	$6.00	$21.00	$219.00	$1.00

TABLE 10B
Farm Expenses

Farm No.	Breeding fees	New buildings	Repairs	Cash rent	Freight	Hay	Grain bought	Feed grinding	Fence
1									
2	$20.00				$20.00		$35.00		
3		$570.00					5.00		
4	5.00		$20.00	$75.00			2.00		$1.00
5				260.00				$5.00	
6				216.00			31.00		50.00
7		300.00	35.00	30.00					
8				360.00	7.00		150.00	4.00	2.00
9		100.00		70.00			20.00		2.00
10	12.00			540.00		$36.00			
11			61.00	101.00				1.00	1.00
12	6.00	150.00		75.00	10.00	125.00		1.00	17.00
13									1.00
14			375.00	25.00			10.00		
15		3,000.00		170.00		290.00	154.00		
16							40.00		1.00
17				160.00			150.00		
18	18.00	22.00	43.00	36.00			62.00		
19	21.00	5.00					5.00	10.00	
20							40.00	3.00	5.00
21			50.00				65.00		1.00
22						280.00			3.00
23		35.00	60.00						
24									
25		90.00		100.00		16.00	30.00		1.00
26		3.00		50.00		25.00	2.00	1.00	2.00
27		771.00					2.00		1.00
28				50.00			25.00		
29			500.00	450.00					100.00
30	3.00			7.00			30.00		10.00
31		300.00	150.00				40.00		2.00
Average	$3.00	$183.00	$41.00	$89.00	$1.00	$34.00	$30.00	$1.00	$7.00

TABLE 10C
Farm Expenses

Farm No.	Insurance	New equipment	Machinery repairs	Machines hired	Silo filling	Threshing	Coal-oil, gas and oil	Time	Auto
1		$100.00	$30.00		$10.00	$12.00	$40.00	$4.00	$75.00
2		200.00		$40.00		23.00			
3	$10.00	135.00	14.00	13.00		12.00		2.00	
4	7.00	65.00	20.00			30.00		7.00	50 00
5			5.00			16.00		3.00	
6		121.00	20.00		12.00				90.00
7	10.00	198.00	5.00	3.00				1.00	35 00
8		8.00	20.00			20.00		9.00	75.00
9			20.00	19.00			2.00	1 00	
10						36.00	4.00	8.00	
11	5.00		6.00				1.00		25.00
12		50.00	65.00	30.00		20.00	3.00		
13			6.00						
14		53.00	3.00				1.00		
15		135.00	15.00				3.00	6.00	
16	7.00		6.00				2.00	5.00	75.00
17			10.00	54.00		100.00		8.00	100.00
18		145.00							37.00
19			15.00	24.00		30.00		3.00	
20		132.00	10.00		53.00		2.00		
21	7.00	79.00	10.00			4.00	2.00	7.00	100.00
22			1.00			22.00	3.00	6.00	
23		250.00				60.00	2.00		10.00
24			15.00						
25		25.00	15.00	16.00	8.00	6.00		5.00	100.00
26		161.00	1.00	5.00		10.00	2.00		
27							1.00		
28	25.00		5.00						60 00
29	15.00		75.00			63.00	25.00	16.00	150.00
30		70.00	5.00	8.00		40.00	3.00	3.00	
31	9.00	215.00	30.00				3.00		230.00
Average	$3.00	$70.00	$14.00	$7.00	$2.00	$16.00	$3.00	$3.00	$36.00

TABLE 10D
Farm Expenses

Farm number	Cow testing	Registration	Grass seed	Seeds and trees	Stamps, etc.	Taxes	Water tax	Veterinary	Farm Bureau	Marketing Assn.	Poisoning rodents	Total
1			$25			$35	$40		$5	$5	$10	
2	$6	$6	100	$30	$2	56	40	$2	5	5	10	
3	8	50				130	40		5	5	7	
4	1		15	77		45	3	1	5	5	14	
5	5				5	55	40		5	5	12	
6				12	5	65	20			5		
7	6	5		25	1	67	20	6	5	5	6	
8	10			25	2	49	2	5	5	5	8	
9	10			20	2	57	24		5	5	12	
10	1			16		37	20		5	5	8	
11			25		2	54	30		5	5	9	
12			35	63	15	22	22	4	5	5	8	
13	6				1	33	20		5	5	12	
14			20	11	34	34	5				5	
15			24	50	2	62			5			
16				27	4	60	20		5	5		
17			40	15	5	100	25			5	15	
18			22	13	5	42	20		5	5	18	
19	3				40	60				5	13	
20	5		14		2	62	3	10	5	5	20	
21	18		10		4	164	60	3	5	5	7	
22				3		30	30				13	
23			8			50	20		5	5	12	
24				12	4	25	10			5	3	
25	10		10	33	1	41	15		5	5	10	
26			20			37	25		5	5	11	
27	24		7	9	2	110	40		3	5	23	
28	5		20	40	5	111	20		5	5	15	
29			80		5	210	60		5	5		
30					10	35	21		5	5	12	
31						130			5	5	15	
Average	$4	$2	$18	$15	$5	$66	$23	$1	$5	$5	$10	$1,016

CAPITAL IN BUILDINGS

The average investment in buildings is comparatively very low at present (1924) as a glance at Table 12 will show. This is because the community is new. As this farming district grows older, more and more capital will be put into buildings and permanent improvements.

Evidently the labor incomes would not appear as large as they do if it were not that the amount of money put into improvements has been very small.[4]

[4]The ingenuity shown by the settlers in the use of materials at hand for buildings and for repairs, the capacity they have shown for "making one hand wash the other" together with their steady industry and thrift have made their labor unusually effective and have given a high apparent labor income in comparison with the capital invested. From the beginning most of the settlers on this project had more labor than capital to invest; this has been the foundation of their well-earned success—Editor.

TABLE 11
Capital at the Beginning of the Year (1924)

Farm number	Farm	Equipment	Feed, seed, and supplies	Live stock
1	$3,000.00	$775.00	$75.00	$427.00
2	4,000.00	1,500.00	100.00	2,930.00
3	8,000.00	800.00	90.00	3,288.00
4	6,000.00	2,500.00	300.00	1,080.00
5	4,000.00	300.00	200.00	1,085.00
6	3,000.00	600.00	100.00	
7	20,000.00	500.00	1,600.00	4,085.00
8	4,000.00	600.00		774.00
9	5,800.00	350.00	200.00	
10	4,000.00	320.00	140.00	1,335.00
11	7,500.00	800.00	270.00	1,205.00
12	7,500.00	1,000.00	625.00	1,612.00
13	9,600.00	500.00	200.00	1,225.00
14	2,500.00	300.00	125.00	
15	5,000.00	400.00	250.00	2,037.00
16	3,000.00	185.00	125.00	2,265.00
17	2,000.00	300.00	150.00	
18	1,000.00	150.00	115.00	
19	4,000.00	400.00	191.00	238.00
20	6,000.00	350.00	250.00	1,330.00
21	8,000.00	250.00	250.00	1,480.00
22	6,000.00	550.00	150.00	
23	19,000.00	400.00		2,139.00
24	4,000.00	200.00	60.00	845.00
25	7,200.00	700.00	175.00	1,445.00
26	3,000.00	775.00	75.00	427.00
27	5,500.00	150.00	50.00	690.00
28	8,400.00	300.00	200.00	2,493.00
29	25,000.00	2,000.00	12,000.00	8,125.00
30	4,200.00	300.00	100.00	428.00
31	11,000.00	1,000.00	1,000.00	3,097.00
Average capital	$6,832.00	$621.00	$618.00	$1,486.00
Average interest	71%	6.5%	6.4%	16.1%

DISTRIBUTION OF CAPITAL

Table 11 contains a tabulation of the distribution of the capital invested: It shows that 71% of the capital is invested in land; 6.5% in equipment; 6.4% in feed, seed, and supplies; and 16.1% in live stock.

TABLE 12
Value of Building

Farm number	Dwelling	Barn	Other buildings
1	$225.00	$250.00	----------
2	5,000.00	500.00	$350.00
3	800.00	----------	375.00
4	1,000.00	100.00	----------
5	1,750.00	1,000.00	500.00
6	300.00	450.00	----------
9	400.00	250.00	100.00
10	675.00	100.00	75.00
11	600.00	100.00	150.00
12	600.00	175.00	100.00
14	200.00	----------	----------
15	1,525.00	----------	200.00
16	750.00	100.00	----------
17	2,000.00	100.00	50.00
18	220.00	50.00	50.00
19	500.00	50.00	67.00
20	800.00	150.00	50.00
21	1,800.00	350.00	300.00
22	475.00	25.00	
23	450.00	175.00	----------
24	385.00	70.00	20.00
25	625.00	50.00	----------
7	500.00	170.00	----------
26	150.00	50.00	----------
27	850.00	100.00	----------
28	3,000.00	500.00	150.00
29	1,625.00	1,500.00	2,150.00
30	300.00	50.00	----------
31	825.00	320.00	----------
Average	$900.00	$190.00	$151.00

TABLE 13A
Summary (Receipts)

Farm number	Increase capital	Crops	Live stock sold	Livestock products sold	Miscellaneous receipts	Total receipts
1	$735.00	$143.00	$146.00	$600.00	$1,060.00	$2,885.00
2	852.00	520.00	258.00	1,144.00	1,705.00	4,479.00
3	2,763.00	376.00	525.00	1,241.00	413.00	5,318.00
4	66.00	191.00	218.00	674.00	464.00	1,613.00
5	774.00	928.00	22.00	756.00	41.00	2,521.00
6	430.00	361.00	335.00	975.00	187.00	2,188.00
7	580.00	212.00	59.00	422.00	339.00	1,612.00
8	90.00	487.00	340.00	1,268.00	112.00	2,297.00
9	485.00	680.00	106.00	611.00	140.00	2,022.00
10	286.00	356.00	105.00	240.00	300.00	1,287.00
11	-602.00	622.00	36.00	574.00	667.00	1,899.00
12	182.00	332.00	----------	39.00	484.00	1,037.00
13	95.00	504.00	18.00	291.00	645.00	1,553.00
14	432.00	----------	15.00	602.00	392.00	1,441.00
15	3,588.00	100.00	318.00	697.00	625.00	5,328.00
16	55.00	810.00	343.00	393.00	34.00	1,635.00
17	1,795.00	1,350.00	----------	1,100.00	1,600.00	5,840.00
18	730.00	360.00	198.00	302.00	728.00	2,243.00
19	610.00	418.00	60.00	680.00	505.00	2,273.00
20	125.00	466.00	156.00	386.00	353.00	1,496.00
21	1,460.00	1,190.00	1,720.00	1,400.00	513.00	4,823.00
22	54.00	78.00	439.00	400.00	370.00	1,331.00
23	1,160.00	296.00	244.00	505.00	153.00	2,258.00
24	50.00	55.00	144.00	430.00	368.00	997.00
25	534.00	370.00	154.00	730.00	700.00	2,478.00
26	487.00	298.00	91.00	334.00	51.00	1,261.00
27	1,543.00	333.00	41.00	694.00	40.00	2,651.00
28	615.00	316.00	318.00	1,339.00	205.00	2,793.00
29	210.00	1,936.00	3,825.00	1,325.00	50.00	7,136.00
30	922.00	316.00	8.00	292.00	454.00	1,992.00
31	1,439.00	----------	1,162.00	1,400.00	----------	4,001.00
Average	$726.00	$461.00	$368.00	$703.00	$442.00	$2,662.00

SUMMARY OF FARM BUSINESS

A complete summary of the receipts and expenses of the thirty-one farms is tabulated in Table 13C. An average figure for all the receipts and expense columns is given at the bottom of the page.

TABLE 13B
Summary (Expenses)

Farm number	Live stock purchased	Farm expense	Total expense
1	$75.00	$1,101.00	$1,176.00
2	40.00	1,350.00	1,390.00
3	1,116.00	1,337.00	2,453.00
4	70.00	708.00	778.00
5	475.00	831.00	1,306.00
6	45.00	835.00	880.00
7	194.00	756.00	950.00
8	40.00	1,015.00	1,055.00
9	128.00	847.00	975.00
10	70.00	20.00	90.00
11	------	622.00	622.00
12	500.00	1,046.00	1,546.00
13	35.00	256.00	291.00
14	35.00	577.00	612.00
15	117.00	4,116.00	4,232.00
16	------	512.00	512.00
17	1,000.00	1,671.00	2,671.00
18	99.00	534.00	633.00
19	220.00	234.00	454.00
20	1,400.00	436.00	1,836.00
21	102.00	1,311.00	1,413.00
22	210.00	391.00	601.00
23	36.00	600.00	636.00
24	1,400.00	124.00	1,524.00
25	50.00	863.00	913.00
26	200.00	368.00	568.00
27	90.00	1,188.00	1,278.00
28	56.00	566.00	622.00
29	134.00	4,024.00	4,158.00
30	692.00	626.00	1,318.00
31	250.00	2,114.00	2,364.00
Average	$286.00	$999.00	$1,285.00

TABLE 13C
Summary (Farm Income)

Farm number	Average capital	Total receipts	Total expense	Income capital and labor	Interest on average capital	Labor income
1	$10,247.00	$2,685.00	$1,176.00	$1,509.00	$615.00	$883.00
2	12,604.00	4,479.00	1,390.00	3,090.00	756.00	2,334.00
3	22,921.00	5,318.00	2,453.00	2,864.00	1,375.00	1,495.00
4	7,720.00	1,613.00	778.00	834.00	463.00	272.00
5	10,162.00	2,521.00	1,306.00	1,215.00	609.00	605.00
6	8,745.00	2,188.00	880.00	1,308.00	524.00	783.00
7	6,085.00	1,612.00	950.00	661.00	365.00	296.00
8	5,530.00	2,297.00	1,055.00	1,242.00	331.00	911.00
9	10,222.00	2,022.00	975.00	1,047.00	613.00	434.00
10	5,728.00	1,287.00	90.00	111.00	340.00	223.00
11	10,436.00	1,899.00	622.00	675.00	626.00	49.00
12	4,382.00	1,037.00	1,546.00	509.00	263.00	-772.00
13	5,153.00	1,553.00	291.00	1,262.00	309.00	953.00
14	2,393.00	1,441.00	612.00	829.00	144.00	685.00
15	6,959.00	5,328.00	4,232.00	1,095.00	419.00	676.00
16	8,253.00	1,636.00	512.00	1,123.00	495.00	628.00
17	12,262.00	5,840.00	2,671.00	3,180.00	750.00	2,444.00
18	5,207.00	2,243.00	633.00	1,610.00	309.00	1,301.00
19	5,705.00	2,273.00	454.00	1,819.00	342.00	1,477.00
20	9,573.00	1,496.00	1,836.00	1,046.00	574.00	472.00
21	25,455.00	4,823.00	1,413.00	1,915.00	1,527.00	423.00
22	7,957.00	1,331.00	601.00	676.00	687.00	13.00
23	8,300.00	2,258.00	636.00	1,626.00	498.00	1,128.00
24	2,425.00	997.00	1,524.00	809.00	146.00	663.00
25	5,403.00	2,478.00	913.00	1,665.00	324.00	1,341.00
26	6,633.00	1,261.00	568.00	693.00	398.00	295.00
27	11,809.00	2,651.00	1,278.00	1,373.00	708.00	665.00
28	11,800.00	2,793.00	622.00	2,171.00	708.00	1,463.00
29	36,220.00	7,139.00	4,158.00	2,768.00	2,173.00	595.00
30	5,489.00	1,992.00	1,318.00	754.00	329.00	425.00
31	16,917.00	4,001.00	2,364.00	1,637.00	1,015.00	622.00
Average	$9,958.00	$2,652.00	$1,285.00	$1,390.00	$604.00	$753.00

VALUE OF HOME-GROWN AND PURCHASED FOOD USED IN THE HOME

After the farmer pays for the expense of operating the farm and the interest on the capital invested he usually has a much smaller amount left than the laboring man doing the same kind of work gets for his services. The farmer, of course, would have long ago quit the land and worked for wages if it were not for the value of the food and fuel he gets from the farm, not taken into account in figuring the income of his labor.

A detailed tabulation of the food used in the thirty-one homes is given in the table below. The average total value of all the food and firewood used in these homes is $441. Added to the labor income, $773, this gives a total of $1,194.

The last column in Table 14 contains the amount spent for groceries and fuel per year. The average for the thirty-one families amounts to $311. This is no doubt much less than the amount spent for groceries and fuel by the average city family.

TABLE 14

Value of Home-Grown and Purchased Food Used in Home

Farm number	Milk	Butter	Eggs	Poultry	Potatoes	Fruit	Garden	Firewood	Other meat	Purchased groceries and meats
1	$110.00	$52.00	$90.00	$60.00	$9.00		$50.00	$70.00	$36.00	$191.00
2	109.00	87.00	54.00	12.00	8.00		15.00	40.00	36.00	239.00
3	180.00	104.00	50.00	9.00	15.00			50.00	70.00	487.00
4	140.00	50.00	37.00	9.00	15.00		25.00		50.00	416.00
5	216.00	37.00	50.00	12.00	15.00	$25.00	100.00	70.00	60.00	379 00
6	55.00	42.00	42.00	15.00	6.00		100.00	40.00	75.00	118 00
7	109.00	26.00	46.00	9.00	6.00		100.00	30.00	18.00	361.00
8	324.00	77.00	37.00	10.00	6.00			50.00	70.00	265 00
9	328.00	78.00	37.00	15.00	15.00			60.00	61.00	314 00
10	104.00	50.00	38.00	9.00	15.00			40.00	36.00	246.00
11	104.00	78.00	43.00	6.00	5.00			40.00	36.00	193 00
12	90.00	52.00	25.00	15.00	24.00			48.00		213.00
13	109.00	50.00	30.00	9.00	8.00		25.00	40.00	24.00	281.00
14	109.00	100.00	37.00	9.00	15.00		100.00	70.00	30.00	275.00
15	306.00	52.00	30.00	18.00	20.00		125.00	75.00	56.00	
16	216.00	125.00	40.00	9.00	25.00		25.00	35.00	60.00	279 00
17	108.00	125.00	90.00	50.00	20.00		150.00	50.00	40.00	890 00
18	80.00	25.00	25.00	9.00	8.00		104.00	50.00	28.00	210 00
19	52.00	25.00	38.00	9.00	6.00		75.00	50.00	36.00	230 00
20	109.00	40.00	50.00	9.00	10.00		60.00	40.00	48.00	290.00
21	109.00	75.00	35.00	18.00	15.00	6.00	150.00	25.00	100.00	467.00
22	100.00	50.00	25.00		5.00			70.00	50.00	189 00
23	216.00	100 00	10.00	9.00	10.00				36.00	328.00
24	109.00	50.00	12.00	6.00	9.00			40.00	36.00	265.00
25	109 00	100.00	57.00	8.00	20.00		50.00	55.00	50.00	434.00
26	81.00	50 00	25.00	3.00	8.00	10.00	125.00	40.00	36.00	161.00
27	163 00	100.00	90.00	24.00	10.00		30.00	50.00	62.00	262 00
28	216.00	100.00	50.00	12.00	18.00		100.00	35.00	50.00	435.00
29	209.00	125 00	125 00	30.00	50.00			45.00	110.00	525 00
30	54.00	125.00	35.00	15.00	9.00		50.00	40.00	50.00	203.00
31	229 00	125.00	92.00	21.00	15.00			20.00	111.00	482.00
Average	$147.00	$75.00	$46.00	$14.00	$14.00	$1.00	$50.00	$44.00	$50.00	$311.00

PERSONAL EXPENSE OF THE FARM FAMILY

It is very interesting to know just how the farmer spends his money for personal matters such as for education, church, reading material, life insurance, travel, and the like.

These thirty-one farmers spent on an average $14 for books and magazines; $33 for church and charity; $190 for clothing; $102 for

doctor bills; $30 for education; $16 for entertainment; $33 for life insurance.

Twenty of these farmers carried life insurance, and each family averaged spending $38 for travel.

The cost of the automobile, charged to personal expense, amounted to $83 per family per year for those who owned machines.

TABLE 15

Personal Expenses

Farm number	Books, papers, magazines	Church charity	Clothing	Doctors, dentists, medicine	Education	Entertainment	Life insurance	Domestic help	Stamps, stationery	Travel
1	$20.00	$60.00	$50.00	$100.00		$50.00				
2	8.00		135.00	20.00					$3.00	$25.00
3	5.00	25.00	200.00	60.00						20.00
4	25.00	60.00	100.00	5.00		25.00	$33.00			
5	12.00	30.00	200.00	100.00		10.00	80.00			75.00
6	15.00	15.00	200.00	170.00		25.00	33.00			20.00
7	9.00	40.00	155.00	200.00		10.00	60.00			25.00
8	6.00	4.00	260.00	400.00		10.00	25.00			25.00
9	10.00	50.00	365.00	50.00		20.00	39.00			40.00
10	12.00	60.00	100.00	35.00						30.00
11	5.00	30.00	450.00	500.00		25.00				100.00
12	10.00	50.00	100.00			15.00			1.00	90.00
13	20.00	50.00	116.00	100.00		40.00	30.00			100.00
14	4.00	10.00	100.00							
15	5.00		150.00			30.00	27.00			
16	10.00	66.00	275.00	13.00		10.00	104.00			
17	19.00	16.00	350.00	25.00			100.00			50.00
18	25.00	26.00	27.00	117.00		20.00			10.00	75.00
19	10.00	40.00	100.00			10.00	38.00			25.00
20	10.00	55.00	150.00			25.00	31.00		2.00	
21	20.00	70.00	300.00			15.00	75.00			60.00
22	6.00	30.00	100.00	80.00			62.00			50.00
23	15.00	45.00	125.00	15.00		10.00				
24	8.00	55.00	200.00	120.00						
25	10.00	12.00	200.00	500.00				$30.00	80.00	
26	15.00	40.00	100.00				57.00		4.00	15.00
27	18.00	60.00	300.00	340.00		6.00	56.00	40.00		10.00
28	8.00	10.00	260.00	50.00			88.00			90.00
29	35.00	100.00	400.00	100.00	$700.00	100.00	62.00			200.00
30	10.00		100.00	28.00	40.00	25.00	16.00		4.00	50.00
31	30.00	15.00	200.00	20.00	180.00	10.00	15.00			
Average	$14.00	$33.00	$190.00	$102.00	$30.00	$16.00	$33.00	$2.00	$3.00	$38.00

MEMBERS OF HOUSEHOLD

The number of children in the thirty-one families visited averaged 1.87 males, 2.13 females per family at home or an average of four children per family. Twenty-nine were enrolled in the high school. Five children from these families are away attending college. All of the young people under the age of 18 years who have not finished a high school course were in school excepting one boy and one girl. There are 69 children enrolled in the grades. The children from all the families but two come to school in a wagon, and ride distances ranging from two to six miles.

EDUCATION OF PARENT

The education of 58 parents visited (there are two widowers and one widow) was as follows:

Two were college graduates.
Four had attended high school four years.
Four had attended high school three years.
Eight had attended high school two years.
Twelve had attended high school one year.
Twenty had finished eighth grade.
Sixteen had not finished the grades.
One was illiterate.

NATIONALITY

All but six of the farmers and their wives were born in America: two were born in Germany; two in Denmark; one in Sweden, and one in England. All the children were Americans, except one girl, who was born in Germany.

The thirty farmers had lived on a farm an average of 30 years, and they averaged in age 42.7 years, and ranged in age from 25 to 66 years. With only three exceptions the farmers were at home 12 months during the year. The wives average in age 39 years, they had lived on farms an average of 33.8 years. They ranged in age from 23 to 57 years. There were 179 people in the homes visited; and an average of 5.7 to the family.

The writer inquired into the knowledge these farmers and their wives had of their ancestry and found that: Four knew their parents only: 26 had some knowledge of their grand-parents; 5 knew great grand-parents. One lady had a fairly complete record of her ancestry down to 1310 A. D.; two others traced their geneaology rather indefinitely back to the Norman Conquest, 1066 A. D.

HOME CONVENIENCES

The home conveniences are few. There are no electric lights, no furnaces, no water in the house and no telephone.

6 have pipeline water outside;
1 has pump inside;
6 have pumps in their wells;
13 have open wells;
2 have spring water;
1 hauls water from neighbor.

Fifteen farmers have gasoline lamps as well as coal-oil lamps. The others burn coal-oil only. The gas lamps cost on an average of $12 per year to operate, and the kerosene lamps cost $7.50 per year. The automobile expense, charged to personal, averaged $83 per family for those owning automobiles.

HOUSE

Practically all of the houses are of frame construction and not plastered. There are an average of 4.6 rooms per house. One house has an inside toilet and bath tub. Four houses have bath tubs but they are not attached to hot water. A tin tub is the only bath tub available in 26 homes.

All of the 31 farmers are land owners. The average amount of the mortgages is $3,445.

CAPITAL REQUIRED TO BEGIN ON AN IRRIGATION PROJECT

The writer asked the farmers how much capital a man should have to begin with on an irrigation project, and their answers ranged all the way from $1,200 to $10,000. Many, however, maintained that $2,000 would be sufficient, but the average of their figures was over

The Diversion Dam—The storage reservoir is four miles farther up the canyon.

$3,000. Quite a number of farmers claimed that too much capital was just as much a hindrance to success as too little. They maintained that a farmer must get a large portion of his living out of the soil, and that if he has much capital he may use it up or waste it and neglect to raise a garden or to milk cows.

SUMMARY

1. The altitude of Metropolis, Nevada, is 5,611 feet above sea level.
2. The annual rainfall is less than ten inches.
3. The soil is a clayey loam under which, in places, there is a limestone hardpan.
4. The native vegetation consists of a luxuriant growth of sagebrush on the higher lands, and of rabbit-brush and some greasewood on the lower lands. There is an unusually large amount of grass for an arid region.
5. The land was reclaimed in 1911 and 1912; and subsequently. Irrigation water is supplied from a reservoir.
6. The dam was built by private capital and the land was owned by a corporation prior to its colonization.
7. There are thirty-three families living on the project. Thirty-one of these were included in this survey.
8. All of the farmers own land.
9. Some farm additional land which is owned by the Metropolis Land Company.
10. The average total acreage farmed is 173 acres.
11. The average acreage cropped per family is 69 acres.
12. Alfalfa and potatoes are the principal crops.
13. The principal cash crop is potatoes.
14. Dairying is the chief source of income.
15. The receipts from crops average $461 per farm.
16. The receipts from sales of live stock average $368 per farm.
17. The receipts from livestock products, principally cream, amount to $703 per farm.
18. The total investment is now $10,016 per farm.
19. Interest on capital was figured at six per cent.
20. The labor income averages $753 per farm. The value of hay was $10 per ton at the end of the year 1923, and only $5 at the beginning of the year. This would, of course, influence the amount of labor income.
21. The labor income is probably $150 higher than the average labor income in the United States.
22. The value of home-grown food used by the family per farm was $441.
23. Cash paid out for groceries amounted to $311 per family.
24. Each family spent:

    $14.00 for books, etc.
    33.00 for church and charity.
    190.00 for clothing.
    102.00 for doctor bills.
    30.00 for education.
    16.00 for entertainment.
    33.00 for life insurance.
    38.00 for travel.

25. According to these farmers a beginner on an irrigation project needs at least $3,000 in ready capital.
26. The average amount of the mortgage is $3,445.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 108 RENO, NEVADA **May, 1925**

The Alfalfa Weevil in Nevada and Its Control by Spraying

By

S. J. SNOW

Assistant Entomologist, Cereal and Forage Insect Investigations, Bureau of Entomology, United States Department of Agriculture

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

FOREWORD

In the spraying tests detailed in this Bulletin the following organizations cooperated:

(1) The Bureau of Entomology of the United States Department of Agriculture.

(2) The Nevada State Quarantine Officer.

(3) The Agricultural Extension Service of the University of Nevada.

(4) The Nevada Agricultural Experiment Station.

The cost of the work was paid in part from the funds of the Station; but more largely from a special fund for alfalfa weevil control appropriated by the thirty-first session of the Nevada Legislature and disbursed by the State Quarantine Officer, Doctor Edward Records. Under this special fund most of the spraying and dusting tests were made by Mr. George G. Schweis.

The Agricultural Extension Service of the University made good use of the tests for the benefit of local farmers in illustrating approved methods of control.

In order to make the work of more than local value, it now seems advisable to publish it as a Bulletin of the Agricultural Experiment Station.

S. B. Doten, *Director.*

HISTORY

The alfalfa weevil was first found in Nevada in 1920, at Tippetts, White Pine County, and near the race track at Reno. It was carried there in some unknown way, probably from Utah.

Its first appearance in the United States occurred near Salt Lake City about 1904. Since then it has spread to nearly all of Utah, part of western Colorado, southwestern Wyoming, southern and central Idaho and eastern Oregon. It has become a serious pest of alfalfa in most of this infested territory, causing a loss ranging up to one-half the yield, where the infestation is severe and no effort at control is undertaken. In addition to this loss and its effect upon the livestock industry, there is the indirect loss and annoyance from the quarantines imposed by certain States.

In the slow spread of the weevil, the flight and the crawling of the adults, or snout-beetles, have been the chief means, aided by winds and the general traffic. There are known to have been only three long jumps by artificial means such as must have occurred in the weevils getting to Reno.

Since its introduction into Nevada it has increased to destructive numbers in the vicinity where first found, between Reno and Sparks and a short distance down the Truckee River, and has spread to other important alfalfa sections. In 1922 it was found at Lovelock in Pershing County. In 1923 a slight extension occurred down the Truckee River as far as Wadsworth and to the west toward Verdi and just beyond the Nevada border into Sierra County, California. During the summer of 1924 weevils were found in Nevada at Fernley and Hazen, on the Swingle Bench, and at Dayton. It has not been found in the southern half of Churchill County, Nevada, nor in Lyon County, nor in the southern half of the State. Slight extensions have been made in White Pine County near the Utah border, and in the productive alfalfa district around Lovelock where weevils can be found in scattered places. It seems probable that the weevil will spread to the remaining portions of the State and continue to be a serious problem.

WORK AND LIFE HISTORY

The injury to alfalfa is done by the little green worms or larvæ which are the young of the weevil. These larvæ hatch from eggs laid by the adult weevils or beetles throughout the spring, and to a slight extent during the preceding fall. The eggs are laid in clusters in the green stems and in the dry grass and alfalfa stems on the ground. The egg puncture in a stem can be seen as a mere speck. When the stem is split open the light yellow eggs are seen in clusters or in rows, varying from 1 to 30 or more. These eggs become darker and less shiny before hatching.

As spring advances the tiny larvæ, one thirty-second of an inch long, hatching from these eggs, emerge from inside the stems and crawl to the tops of the alfalfa plants and there feed inside the growing buds. Later they feed upon the tender leaves and branches and, as they get larger, are often seen curled over the edge of a leaf or around the stems.

They are slightly lighter in color than the alfalfa and have a black head and a light stripe running down their backs.

When mature they are one-fourth to five-sixteenths of an inch long; they then crawl lower down on the plants or to the ground, spin silken, net-like cocoons and transform to adult weevils. The length of time occupied by the different stages varies a great deal, mainly according to temperature. The egg stages usually last for ten days to two weeks; the larval or "worm" stage, five or six weeks; and the pupal or cocoon stage, a week to ten days.

The larvæ become most numerous during late May and early June and continue feeding until, if the infestation is severe, the plants are riddled. Sometimes the upper branches are stripped of leaves or the epidermis is eaten from the leaves to such an extent that they look skeletonized. Several yards or rods away fields that are badly damaged take on a characteristic whitish or "silver-gray" appearance.

If no means are used to destroy the larvæ they kill the tips of the plants and prevent further growth. Hay from such fields is of poor quality and of greatly reduced tonnage. When the crop is cut, the larvæ which have not become full-grown fall off or leave the drying alfalfa and congregate upon the growing shoots of the second crop. A few larvæ can destroy the tender shoots of each crown as fast as they come up. Where the first crop has been cut early, while few of the "worms" are full-grown, the delay to the second crop in getting a start may be three or four weeks, thus preventing a full second crop or a full third crop where three cuttings are the rule.

When most of the larvæ mature and stop feeding to spin cocoons, the second crop begins to overcome the feeding of the remaining larvæ and, after it once gets a start, is never retarded by the straggling larvæ feeding throughout the middle of the summer. On the contrary, if the first crop is cut late, say in the latter part of June, there is no delay to the second crop because by that time nearly all the larvæ have passed into the cocoon stage. Regardless, therefore, of whether the field is cut early or late, if no control measures are used, injury results either to the first or to the second crop or to both.

No damage occurs later in the season because the young adults emerging from the cocoons in late May and June, though they do some feeding, cannot lay eggs until late in the fall of the same year or the next spring, and because the old adult beetles, after their heavy egg-laying in May, die off rapidly and the remaining ones lay few eggs throughout the summer. Larvæ hatching from these summer eggs are never numerous enough to be noticed. Enough beetles of the new generation may survive (and will more than likely survive) the summer heat and the winter cold to produce enough larvæ to cause some injury every spring. Whether enough larvæ will be produced, or be hatched out in such a way as to concentrate their feeding and cause damage sufficient to warrant spraying every spring, is an important but unsettled question. Other factors having to do with climate, parasites, farm practices, etc., may prevent such damage during certain years or every year, but, on the other hand, the danger of severe injury exists and presents to the growers of alfalfa the problem of how best to secure control.

NATURAL CONTROL

Control is of two kinds, natural and artificial. Natural control takes place when the weevils are prevented from being injurious by disease, the attacks of predaceous and parasitic insects and other animals and by unfavorable surroundings and climatic conditions. Among the predaceous enemies are several species of birds and insects. Insect parasites of the egg, the larvæ and the pupa have been introduced from Europe, and one species, *Bathyplectes curculionis* Thoms., a small wasp-like "fly" in the adult stage, has become common throughout the weevil infested territory and often kills a majority of the weevil larvæ. Cool and damp weather throughout the spring and hot bright weather after haying time appear to have controlled the weevil in Utah during certain years. While these climatic conditions destroy weevils every season, it is probably some combination of all the factors which keeps the weevil down to the point where it is not injurious in certain years.

ARTIFICIAL CONTROL

Among the various methods of artificial control which have been tried the following have proved satisfactory: Spring cultivation of alfalfa fields, pasturing, brush dragging or the dust mulch method, and spraying and dusting with arsenical poisons. Properly timing the cutting of the first crop, or successive cuttings, is sometimes effective.

Early spring cultivation is an indirect method in that it destroys weeds and grass and stimulates the growth of the alfalfa, thus helping it to overcome the attack of the weevils later in the spring. It is of little benefit, however, in killing the two stages of the weevil present in the fields at this time of the year—the overwintering beetles and the overwintering eggs in the dry grass and alfalfa stems.

Pasturing, especially with sheep, during the egg-laying period of April and May removes the eggs and newly-hatched larvæ almost as fast as they appear. This method of control demands careful attention to the stock and is practicable only under certain kinds of farm practices. Its success depends upon grazing parts of a field at alternate times and continuing this practice until nearly all the eggs have been laid. It has the disadvantage of often causing bloating and of using up the first crop which is generally needed for winter feeding.

The brush dragging method, popular a few years ago, consists of dragging the field, after the first crop is cut, with a brush or wire drag weighted down with a harrow or leveler, until all the vegetation is removed, the clods broken up and the surface covered with a dust mulch. This process incidentally kills some of the larvæ, pupæ in cocoons and newly-hatched adults, but its effectiveness comes from the fact that it exposes these stages of the weevil to the killing heat of the sun. If the weather is warm and bright, enough weevils are killed to permit the second crop to start immediately. This method works well on fields that are free from grass and rocks, but it has its faults; it does not protect the first crop, and it must be done at haying time which is one of the busiest periods of the year.

Making two cuttings of the first crop, say when the alfalfa first begins to show injury (about the middle of May when it is 15 to 18 inches high) and again about two weeks later, has much the same effect as pasturing in removing the eggs and young larvæ before they do

much damage; but, like pasturing, it requires close attention and skill in determining the proper time to apply the method and it is seldom adapted to farming practices in the Great Basin States. One cutting, under certain conditions, may have the same effect as two, if it is properly timed to remove the bulk of the eggs and young larvæ and luckily followed by bright, hot weather to expose to the heat of the sun the larvæ that fall to the ground, as in brush dragging. This method, however, must not be confused with "early cutting" as used by many farmers when, just previous to the regular cutting, they see their alfalfa is badly eaten up by the weevil and attempt by cutting immediately to save the first crop and give the second crop an early start. Cutting at this time is usually a failure in both respects and results in an immature first crop and exposes the second crop to the feeding of the larvæ at the height of the weevil attack. A field north of Sparks, Nevada, was cut June 4, a day before the spray outfit arrived, in order to "save the first crop and get an early start on the second." For over two weeks the larvæ kept the field bare, whereas on sprayed fields nearby the second crop came up immediately.

SPRAYING AND DUSTING

In recent years spraying and dusting with arsenical poisons have come to be regarded as the best methods of control. The former may be said to be the standard treatment for the weevil, while dusting, though now used only experimentally, is about as effective. It promises to become the cheaper and more easily applied method of the two and may replace spraying.

Fruit growers and truck-crop gardeners have long used successfully both the liquid spray and the poison dust, but when these practices were proposed for killing insects on a field crop such as alfalfa, they were thought at first to be impracticable. Spraying for the alfalfa weevil was first developed and improved by the Bureau of Entomology of the United States Department of Agriculture several years ago and has been tried extensively and successfully in Utah, Colorado, Idaho, and Oregon. The object of both methods is to cover the alfalfa plants with a light application of the poison to kill the weevil larvæ during the period of heavy feeding in the spring.

Such poison never injures the hay as feed. At cutting time too little poison remains to make the hay dangerous. Spraying and dusting have advantages over other methods since they are practicable on all types of fields, can be done at a time when farmers are not busy, and are effective and profitable. Spraying with some of the new traction machines now on the market can be done by one man and a team, at the rate of 20 to 30 acres a day and at a cost under $1 per acre.

Spraying in early spring to poison the beetles before the eggs are laid and spraying the stubble after the first crop is removed have been partially successful, but the conditions which govern their success are not understood and they are therefore not recommended.

While the results of dusting have usually been good, in the application of it there has been uncertainty as to the amount of dust which sticks to the alfalfa, or should stick to be effective, and as to the reasons for its sticking at one time better than another. It was thought that the day must be calm and that dew on the plants was

a big help in making the powder stick. Much progress was made in 1924 through experiments which indicate that the attraction which various kinds of poison dust have for alfalfa depends upon the electrical charge they receive as they leave the dusting machinery. Much remains to be done in improving the dusting machinery on the market and adapting it to alfalfa dusting, with particular reference to the way the powder is fed from the hopper.

SPRAYING AND DUSTING IN NEVADA

In the spring of 1924 spraying demonstrations and a dusting experiment were conducted at Reno, Nevada, by the State in cooperation with the United States Bureau of Entomology. In 1923 the State conducted spraying demonstrations in the same locality. Fair success attended these rather extensive spraying projects, especially in 1924. Their purpose was to show the growers of alfalfa the treatment for the weevil used in other western States and to determine wherein conditions in Nevada would demand changes in the spraying method. It was believed that, if the demonstrations were successful after the farmers on the ground had been shown how and when to spray, then the other districts throughout the State should know of the results in order to combat the weevil properly whenever it becomes injurious.

DUSTING EXPERIMENT

The results of the dusting experiment were fairly satisfactory and should be considered as suggestive in future experimental work.

The machine used was a Johnson Traction Duster with a homemade boom. A two-wheel truck carried a small hopper and a blower on a platform about five feet square, with plenty of room for a driver's seat and sacks of poison. Traction power and chain drive ran the blower and the agitator in the hopper. The boom was made of galvanized iron, 19 feet long and about four inches in diameter at the center, and tapered gradually to three-fourths of an inch at the ends. The center was a four-inch T-shaped tube, the base of which fitted snugly into the feed pipe from the blower. The boom was fastened by J-bolts to a 4x4 timber resting on the rear of the platform and extending slightly beyond the wheels. In going through gates the two ends of the boom were pulled out of the center piece after the end J-bolts had been loosened. On the under side of the boom and throughout its entire length, holes three-sixteenths of an inch in diameter were drilled in a row about one and one-half inches apart, through which the powder was discharged. It was blown out of all the holes at about the same rate, due to the tapering boom, except that less powder came from the holes near the ends when the amount in the hopper became low.

A field of 15 acres belonging to A. Tachino on the highway between Reno and Sparks was selected for the dusting. The alfalfa was 20 to 24 inches high, of heavy stand, and most of it badly injured by the weevil. Like most fields in the valley, the injury was worse in certain portions, with the difference not clearly marked or always easily seen. Some portions could be detected from the highway several rods away, for they looked yellowish, as if partly frost-bitten. This condition had been apparent for over a week, but seemed not to get much worse, due to the healthy growth of the plants and the heavy stand. It is prob-

Dusting Machine in Operation.

Traction Sprayer in Operation.

able, therefore, that the field might have escaped any more serious injury, and it is also probable that better results could have been obtained if dusting had begun a week earlier.

Three plots were laid out in the field and dusted on June 9 and 10 with calcium arsenate and sulphur, lead arsenate and sulphur, and straight lead arsenate respectively. The sulphur at the rate of four pounds to one of the poison was used as a filler because in earlier experiments in Utah, Colorado and Idaho it had been found to be necessary for good results. The amount of poison per acre could not be properly regulated and accurately measured, but was estimated at from two to four pounds. About half an acre adjoining each plot was left undusted as a check. The machine delivered the dust satisfactorily most of the time, except that the back pressure blew the powder out of the top of the hopper and greatly decreased the flow in the boom when the dust in the hopper got as low as three or four inches from the bottom.

The plots which were dusted June 9 and 10 were swept with an insect net during the following week and the number of larvæ caught for each 100 strokes of the net, as given below, shows that there were about one-fourth as many in the dusted as in the undusted parts.

Average Number of Larvæ Per 100 Strokes in Dusted and Undusted Plots

Plot No.	*Dusted with*	*Dusted Plot*	*Check*	*Per cent Killed*
1	Calcium arsenate and sulphur	331	1,222	73
2	Lead arsenate and sulphur	297	804	63
3	Straight lead arsenate	221	834	73

SPRAYING IN 1924

In repeating the spraying demonstrations in 1924, in cooperation with the United States Bureau of Entomology, it was thought that better results could be obtained if more attention could be given to working out the seasonal history of the weevil, properly timing the spraying and seeing that the machines worked right. In order to study the spring seasonal history of the weevil in the Truckee Valley, that is, in order to learn how numerous the eggs, larvæ and adults were at different times, observations were made in the same fields throughout May and June, mostly by two assistants from the University of Nevada, Mr. J. J. McElroy and Mr. R. M. Clawson.

These men worked some of their afternoons during May and Mr. McElroy, after school closed, continued throughout June as a full-time assistant. In order to determine how numerous the weevils were in different localities, how many farmers desired their fields sprayed and which fields were injured sufficiently to warrant spraying, trips of inspection to different localities and fields were made occasionally with Mr. Thomas Buckman, the County Agent, and, later on, with Mr. George Schweis, in charge of the spraying machines. When spraying began, three fields were selected for close study and nearly all observations as to the effect of the spray were confined to them. During the days spent in these fields air and soil temperatures and relative humidity readings with a sling psychrometer were taken approximately every hour.

DETERMINATION OF INJURY

Field observations on the activity of the weevils and the numbers present were begun April 29 when the alfalfa was 2 to 3 inches high. Adult weevils were not easily seen or found. It took a close watch of 10 or 15 minutes usually to find one crawling on the ground or feeding on the plants. Having a color resembling the soil they were difficult to see, and when some one approached them they usually fell off of the plants or crawled out of sight. When the alfalfa became higher, they were caught by sweeping the tops of the plants with an insect net. By comparing the number of specimens caught from the same number of similar strokes of the net, it was possible to tell how relatively numerous the weevils were in different fields and at different times. The number of adults caught per 100 strokes of the net increased steadily from 6.6 during the middle of May to 48.3 during the middle of June.

TABLE I

Showing Average Number of Adults and Larvæ of the Alfalfa Weevil Caught During May and June. (Months Divided into Approximately Equal Periods for Convenience.)

	Per 100 Strokes of the Net	
Time	*Adults*	*Larvæ*
Middle of May	6.6	222.1
Late May	16.9	1,309.9
Early June	28.7	1,693.0
Middle of June	48.3	832.0
Late June	26.1	216.2

No sweepings from sprayed fields included.

The increase in the number of adults caught throughout May is partly accounted for by their increased activity while the increase in the first part of June is largely due to the emergence from the cocoons of the new generation of weevils. The decrease in late June to 26.1 may have been partly due to poorer collecting conditions, since fewer weevils remain near the tops of the plants as the summer heat increases and since the fields from which collections were made in late June were not so heavily infested as other fields which had been cut and from which collections had been made earlier. The dying off of the old weevils may also have caused part of the decrease in the collection in late June.

Eggs were found by splitting or carefully examining the green alfalfa stems and by splitting the dry grass and alfalfa stems on the ground. During early May 2.4 clusters of eggs were found per 100 green stems, equally divided between freshly laid eggs and old eggs. Eggs were found in greatest numbers during the middle of May when 4.5 clusters occurred per 100 green stems. June showed a sharp decrease, with the remains of hatched egg clusters far outnumbering the unhatched, indicating that the egg-laying season had passed.

The number of clusters found in green stems was too small to account for the amount of feeding noticed one or two weeks later or for the number of larvæ caught at any time. One-half or more of the larvæ must have come from eggs laid in the dry stems, and this deduction is borne out by the fact that dry stems examined in June showed an average of 5.4 clusters per 100 stems. These consisted mostly of hatched clusters. Moreover, at the beginning of the season nearly all

the newly-hatched larvæ were found on stems in which no eggs at all had been laid, showing that such larvæ had come from dry stem eggs. Exactly what proportion of the eggs are laid in the dry stems in any particular season or field is an important question dependent upon the weather and the condition of the field. The number is smaller when the season is too cool for much oviposition throughout the early part of the spring and subsequently turns suddenly warm. As to the effect of the condition of the field upon egg-laying, more eggs appear to be laid in dry stems in fields with an abundance of grass, the hollow, dead stems of which lie on the damp ground and are favored by the adults for egg-laying.

The weevil larvæ were scarce in early May. Out of 2,200 green stems examined, only 123 small, and 3 medium-size larvæ were found feeding in the tips. By the 10th of May the alfalfa became high enough to sweep with a net and the catch from the sweeping was therefore depended upon as indicating the number of larvæ present. This is a better gage for larvæ than for adults since the former feed continuously at the tops of the plants, do not fall off when disturbed, and therefore are more likely to be caught in the net.

During the middle of May larvæ increased, as shown in Table I, from 222 per 100 strokes of the net to 1,693 during the first part of June and then decreased steadily to 216 during late June. This decrease would probably have continued in a steady manner but was hastened by the cutting of the first crop, which abruptly removed many larvæ. By July 22 sweepings from the second crop yielded only 1.4 larvæ per 100 strokes.

TIME TO SPRAY

Over 300 larvæ per 25 strokes were caught during late May, as shown by reducing figures in Table I; 25 strokes is the most convenient number to take when larvæ are numerous. The presence of about this number of larvæ in most of the fields indicated that there would be injury and that spraying would probably be necessary. Some fields yielded more and some less, and nearly every field varied in different portions in the number of larvæ caught and in the amount of larval feeding noticeable. Many farmers, seeing the feeding marks and finding larvæ in the tips, were unnecessarily alarmed and wanted to begin spraying immediately.

It should be pointed out here that alfalfa which is growing normally can withstand a considerable amount of early feeding without suffering serious injury or having the tonnage appreciably reduced later on. It should be remembered, moreover, that the spray, if applied at the first signs of feeding, may kill the larvæ causing the injury, but will wear off or become ineffective, due to new growth, within a week or ten days and consequently fail to kill the larvæ hatching thereafter. Spraying a little late is better than spraying too early if but one application of the spray is planned. The Asylum field at Reno just before spraying gave over 1,000 larvæ per 25 strokes, but after spraying it recovered and within a week looked green again.

The number of larvæ present as spraying time approaches is not a convenient or reliable method for the average farmer to use in determining the time to spray, since, for one reason, the catch from an insect net varies according to its size and the manner of sweeping; no

two men sweep exactly alike. Some fields, moreover, with thin stands and poorly growing alfalfa, showed sufficient injury to warrant spraying, although the number of larvæ was very much smaller than 300 per 25 strokes, whereas other fields with heavy stands and with rapidly growing plants withstood the feeding of about 1,000 larvæ per 25 strokes without getting beyond recovery through spraying.

For all practical purposes the best time to spray, as shown by previous experience, is just as the alfalfa begins to look grayish. This slight change of color is caused by the feeding marks of the larvæ and indicates the degree of injury which is the important point. It usually occurs when the larvæ becomes as numerous as shown in Table I for late May, although much depends upon the condition of the alfalfa. Fortunately, there is a period of several days, extending from the time the color begins to change, when the spray can be applied successfully, and if spraying cannot be done during the first part of this period, it is recommended that it be tried during the following week or ten days. During this period, if the injury is severe, the alfalfa will probably become more yellowish or whitish and only in extremely unfavorable conditions will it go beyond the point of recovery. The beginning of this period when spraying should be done generally occurs two to three weeks before the first crop is cut.

THE SPRAYING MACHINERY AND MATERIALS

Preparations for the spraying demonstrations were begun about May 20, a few days previous to the time when the first fields began to look whitish. The two Bean Power Sprayers used in 1923 and a new Iron Age Traction Machine were overhauled, braces added to strengthen the booms, platforms and guards built and other improvements made, including a double acting hand pump on the Iron Age Sprayer for filling the tank.

The main parts of these sprayers consisted of an engine in case of the power sprayers, a 100-gallon tank and pump with a pressure gage mounted on a cart or truck, and a long boom supporting the nozzles. The pump was connected with the tank by a thick suction hose and with the center and end parts of the boom by one-half inch or three-quarter inch pressure hose. On top of the tank there was an opening into which fitted a box-like funnel with a forty-mesh brass screen through which the water and poison passed as the tank was filled. An agitator inside the tank stirred the liquid constantly and kept the poison in suspension. The boom was divided into three parts, one portion stationary, directly behind the tank, and the two ends movable so that they could be raised in passing through gates. These parts consisted of one-half inch iron pipes about two feet long joined by T's, the third opening of each T being for the attachment of the nozzle. The nozzles used were of the hollow-cone type with the opening in the disc about one-sixteenth of an inch in diameter. The boom was adjusted so that the nozzles usually pointed straight downward and sometimes at a slight angle outward.

Spraying began May 26 and ended June 13. The actual time consumed was 241 hours. Portions of 18 farms were sprayed, totalling 526 acres, or at the rate for all the machines of about 22 acres a

day. At a pressure of 150 to 225 pounds the contents of the 100 gallon tank covered 1½ to 2 acres, so that in order to apply the necessary amount of 2 to 3 pounds of poison per acre, 3 to 4 pounds of calcium arsenate were placed in each tank full of water. Experience has shown that calcium arsenate is the best material for this purpose.

THE COST

The cost of these demonstrations was mostly borne by the State through an appropriation of the Nevada Legislature to the State Quarantine Service. Each farmer furnished a team and a driver. The expense of repairing and maintaining the machines was secondary and no effort was made to cover the greatest number of acres at the least expense or in the shortest time. In calculating the cost to the farmer who does his own spraying or who pools his interest with a group of others in having it done, the initial cost of rigging up an outfit or of purchasing a new one is the main expense.

There are four traction sprayers on the market that have been used successfully in both Nevada and Idaho; they cost about $300 each. These machines should last from 10 to 15 years; but no figures are yet available as to the depreciation or the cost of overhauling and making repairs. Much depends upon the care of the machines, the time used each year, and the condition of the roads and fields. In calculating the number of acres a machine can spray each day and the number of days during which spraying can be done each spring, there are available more definite figures, but here again the figures vary according to the condition of the fields, the man and the team, and the location or availability of the water supply. The average number of acres sprayed per day for the Iron Age machine, for instance, was about 24. This machine operated during the whole period when spraying was advisable and covered 320 acres. It was timed on a few occasions and found that the tank could be emptied in 15 to 18 minutes and filled by the hand pump in 4 or 5 minutes. The full tank, as stated earlier, usually covered 1½ to 2 acres.

This would be at the rate of 4 to 5 acres an hour or 40 to 50 acres a day if steady spraying and filling were engaged in to the exclusion of everything else. Discounting these figures and relating them to what was actually accomplished, it would be safe to say that a machine can spray 25 acres a day and 300 acres during a season. At the season when spraying takes place, the time of the farmer and his team ought to be available without adding extra cost to the ordinary expenses of farming. On the basis of these considerations, we may make the following rough estimate of the cost of spraying:

Cost of spraying apparatus, $300. Per acre (assuming 300 acres a year for 10 years)	$0.10
Annual interest on investment at 7%, per acre	.07
Overhauling, repairs and fuel, per acre	.05
Calcium arsenate, 2 lbs. per acre, at 15c	.30
	$0.52
One man, if employed to drive team at $4 per day and covering 25 acres, per acre	$0.16
Total per acre	$0.68

RESULTS OF SPRAYING

In order to learn what effect spraying had upon the appearance of the alfalfa and especially upon the number of larvæ and adults, three fields were selected, as previously stated, for close study. Two of these fields were situated northeast of the University at Reno where the weevil was first found in the Truckee Valley. About 35 acres of gently sloping ground with soil of clay loam and good drainage was divided into plots for study. This was about two-thirds of the total alfalfa acreage on these two farms, which had been sprayed in 1923. The other field was located about four miles east of Reno and just south of Sparks. About 12 acres of level lowland having fair drainage was selected here. There were several fields in the vicinity, none of which had been sprayed in 1923. The alfalfa on all three fields was several years old and of good stands, the two near the University containing some grass.

These fields were divided into a total of seven plots, each having a representative portion left unsprayed as a check. All plots were treated alike, except that two received a slightly greater amount of poison per acre. Five were sprayed with the Iron Age and two with one of the Bean Power Sprayers. Each field was visited about every third day and the plots and checks swept with a collecting net. The adults and larvæ thus collected were counted on the spot usually after every 25 strokes. The catch from the net was emptied onto a newspaper spread out on the ground and the weevils brushed aside as they were counted. The plots were sprayed from May 25 to May 29 inclusive. The weather during this time and up until cutting time was clear, warm, and frequently windy, but without rain.

EFFECT UPON ADULTS

The number of adults caught in the sprayed plots compared with the number caught in the checks varied slightly from day to day and from field to field. In about 10,000 strokes of the insect net taken in June, there were 39.2 adults caught per 100 strokes in the plots and 29.0 in the checks—a rather remarkably equal division. A few days after spraying there was a striking reduction in the number of adults in the sprayed portions in all seven plots, but this difference did not continue to exist as shown by the following statement:

Showing Average Number of Adults 2 to 14 Days After Spraying

	Per 100 Strokes	*Sprayed*	*Unsprayed*
Plot 1—	3 days after spraying	6.2	16.0
	6 days after spraying	10.0	16.0
	12 days after spraying	51.6	40.0
Plot 2—	2 days after spraying	2.6	80.0
	5 days after spraying	6.0	50.0
	8 days after spraying	6.4	0.0
Plot 3—	5 days after spraying	9.0	44.0
	8 days after spraying	23.5	17.3
	12 days after spraying	85.3	86.0
Plot 4—	7 days after spraying	2.0	36.0
	10 days after spraying	11.2	34.6
	14 days after spraying	35.2	41.6
Plot 5—	5 days after spraying	3.6	33.3
	8 days after spraying	12.6	6.0
	12 days after spraying	38.7	32.8

		Sprayed	Unsprayed
Plot 6—	3 days after spraying	11.5	20.0
	7 days after spraying	22.6	15.0
	10 days after spraying	35.3	16.6
Plot 7—	2 days after spraying	4.0	50.0
	6 days after spraying	12.0	28.0
	13 days after spraying	81.6	46.2

Thus there were seven times as many beetles found in the unsprayed as in the sprayed plots during the first week after the treatment. A total of the first figures for each plot above gives 38.9 for the sprayed and 279.3 for the unsprayed. This reduction in numbers after spraying does not necessarily mean that the beetles were either killed or repelled by the poison, but only that they were absent from the tops of the plants where they would have been caught in the net if present. The fact that they were as numerous as in the checks later on either shows that they were not killed or that their spread from the checks to the plots equalized matters or offset the effect of the spray. These results are in line with what has been found to be the case in other States and in other years. The conclusion is drawn that the adult weevils after feeding for a few days upon the sprayed alfalfa become sick and stop feeding for a few days and then recover and return to the tops of the plants, by which time the effects of the poison have worn off and the plants have put out a new growth. This conclusion is supported by laboratory experiments in which adults have been fed sprayed alfalfa and by field observations which have shown that they are sluggish and act sick for a few days after a field has been sprayed.

EFFECT UPON THE LARVÆ

The reduction in the number of larvæ in the sprayed plots is the important factor since they, rather than the adults, cause the injury, and the reduction must be permanent and large enough to remove many thousands of them per acre to make spraying successful; that is, it must leave so few that the plants can grow faster than the larvæ can injure them. To do this, over one-half of the larvæ usually must be killed, depending upon the time of the spraying and the season, the degree of infestation and the condition of the field. In all the seven plots and in the miscellaneous fields the number of larvæ in the unsprayed portions was at all times, except once, very much larger than the number of those sprayed, ranging up to nearly 40 times as many and averaging 7.55 times as many for all the observations taken in the month following the spraying, involving nearly 13,000 strokes of the net.

The following statement shows the average number of larvæ caught in the sprayed and unsprayed portions of one of the plots of each field for a few weeks after spraying:

Average Number of Larvæ Per 100 Strokes

Field 1, plot 2 (J. L. Raffetto). Sprayed May 28—	Sprayed	Unsprayed
At time of spraying	831.5	831.5
2 days after spraying	485.3	1,096.0
5 days after spraying	336.0	1,956.0
8 days after spraying	104.8	1,454.0
12 days after spraying	96.5	725.0
13 days after spraying	18.3	436.0
15 days after spraying	26.3	686.0
19 days after spraying	19.6	443.0
26 days after spraying	7.7	128.0

Field 2, plot 1 (A. Ramelli). Sprayed May 27—	*Sprayed*	*Unsprayed*
At time of spraying	1,611.2	1,611.2
6 days after spraying	396.6	2,992.0
9 days after spraying	236.0	3,304.0
13 days after spraying	133.2	3,004.8
16 days after spraying	62.8	2,114.4
19 days after spraying	57.5	1,232.0
20 days after spraying	50.0	632.0
Field 2, plot 2 (C. J. Christianson). Sprayed May 29—		
At time of spraying	536.6	536.6
2 days after spraying	1,988.0	4,230.0
6 days after spraying	520.0	2,006.0
13 days after spraying	381.6	692.0
16 days after spraying	436.0	902.0

The figures for the sprayed and unsprayed portions at time of spraying represent a field average.

Similar results are obtained if each field be taken by itself combining the figures from the various plots. Since the whole field was not sprayed on the same day, the figures are tabulated by dates instead of by the number of days after spraying:

Field 1, all plots (Sprayed May 27–28)—		
June 2	635.2	1,840.6
June 5	260.8	1,642.4
June 9	130.3	644.5
June 10	18.3	436.0
June 12	51.5	795.6
June 16	32.4	393.4
June 23	13.2	302.2
June 24	12.0	152.0
June 26	9.3	145.0
June 27	7.3	102.4

Average Number of Larvæ per 100 Strokes

Field 2, both plots (Sprayed May 27–29)—	*Sprayed*	*Unsprayed*
June 3	309.2	2,048.8
June 6	111.2	2,582.4
June 10	71.7	2,324.0
June 13	115.0	1,567.1
June 16	57.5	1,232.0
June 17	50.0	632.0
Field 3, both plots (Sprayed May 28–29)—		
May 31	1,848.4	2,624.0
June 4	646.9	1,764.0
June 7	666.7	1,864.0
June 11	330.7	1,006.0
June 14	565.1	1,225.1

This statement shows the results by periods for June:

Field 1, plot 1 (Sprayed May 27)—	*Sprayed*	*Unsprayed*
Early June	235	502
Middle June	23	236
Field 1, plot 2 (Sprayed May 28)—		
Early June	147	1,128
Middle June	17	445
Field 1, plot 3 (Sprayed May 28)—		
Early June	447	1,559
Middle June	38	370
Field 2, plot 1 (Sprayed May 27)—		
Early June	233	3,092
Middle June	57	1,300
Field 2, plot 2 (Sprayed May 29)—		
Early June	119	1,452
Middle June	82	1,305

	Sprayed	Unsprayed
Field 3, plot 1 (Sprayed May 29)—		
Early June	670	1,775
Middle June	424	1,400
Field 3, plot 2 (Sprayed May 29)—		
Early June	520	2,006
Middle June	402	738
Miscellaneous fields—		
Early June	106	1,602
Middle June	84	705

EFFECT UPON THE CROP

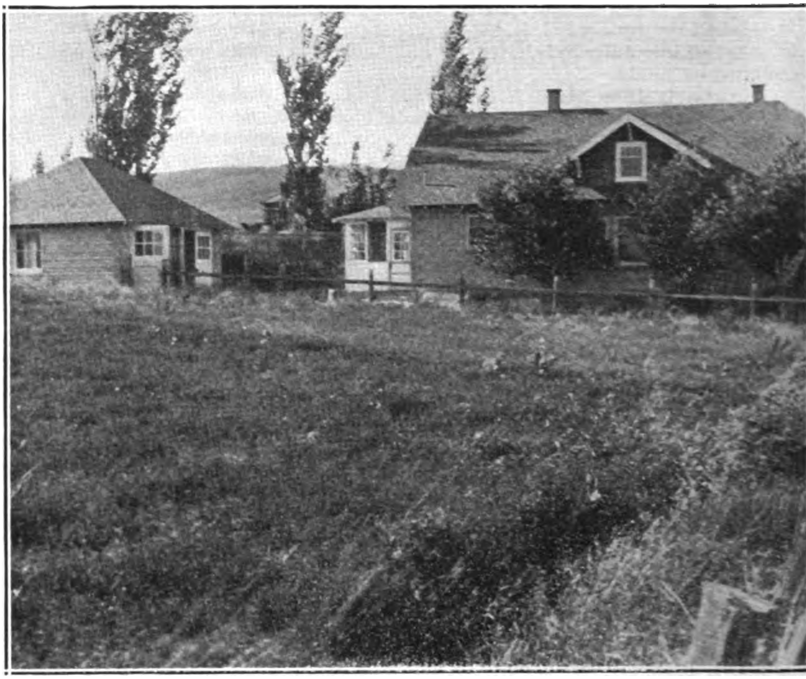
The appearance of a field about a week after spraying is the practical indication of the success or failure of the spray. In almost every field sprayed the line of demarcation between the gray of the checks and the green of the plots sprayed was noticeable, in some cases a few feet away and in others several rods or a quarter of a mile away (see pictures). The checks varied from a slightly yellowish tinge to a distinctly whitish color, depending upon the degree of infestation and the way the alfalfa was overcoming the injury, while the sprayed portions took on a greener appearance. Although the feeding marks made before or just after spraying persisted until cutting time, they were concealed by a new growth at the tips. Grass in many fields prevented the plots from showing up in contrast to the checks. Cutting was generally early and several fields were cut about ten days after spraying, too early to get the full benefit of the spray. In a few lightly infested fields the alfalfa overcame the injury in the checks so that the apparent difference between the checks and the plots disappeared in two or three weeks after spraying and was shown only by the greater number of feeding punctures noticed in the checks.

After the first crop was cut the difference in the appearance of the plots and the checks was not apparent except to a slight extent in one or two fields, and persisted for only three or four days. Instead of being delayed as usual, the second crop on all the checks, with the slight exceptions just noted, came up immediately after cutting and as fast as on the treated plots.

It will be seen that Field Number 2 showed the greatest contrast between the sprayed plots and checks. This was a field which received a slightly greater amount of poison per acre, two and two-thirds pounds per acre (four pounds per tank full of water applied to one and one-half acres) while the other fields received two pounds per acre. It appears that the better results were due to the greater amount of poison applied; two pounds per acre, however, gave good practical results, as it has done in other years.

SECOND SPRAY

From a report of the results in 1923 it was thought that two applications of the spray might sometimes be necessary, as for instance when the poison has been rendered ineffective by a heavy rain soon after spraying or when, as in some seasons in western Idaho, the hatching of the eggs is extended over a such a long period and the feeding of the larvæ is so prolonged that the later ones are able to feed upon the new growth which has appeared since the spray was applied. No second spraying was needed in 1924, but for experimental purposes six acres in two different fields were sprayed again on June 10, two weeks after



Alfalfa Fields After Spraying. The Lighter Portions are the Check Plots which were Left Unsprayed.

the first application, and the number of larvæ was still further reduced, as shown below:

Average Number of Larvæ Per 100 Strokes

		Two sprays	*One spray*	*Check*
Field 1, plot 3 —	June 12	209.6	120.6	1,167.0
	June 16	12.0	50.1	570.0
	June 23	4.0	22.0	389.3
	June 25	2.1	12.0	152.0
Field 2, plot 1 —	June 10		133.2	3,004.8
	June 13	83.6	62.8	2,114.4
	June 16	19.5	57.5	1,232.0
	June 17	3.2	37.5	632.0

A second spraying is necessary under certain climatic conditions, but under those of western Nevada a single thorough treatment should be enough. Where two are necessary, the second should be applied a week or two weeks later, after the first has been outgrown and the fields begin to show injury again.

Some false hopes have arisen regarding spraying. It will not get rid of the weevil, and it is not certain that, even if every farmer in the locality were to spray, the number of weevils which survived to produce larvæ the following spring would be sufficiently reduced to make spraying unnecessary the second year. There are variations in weevil damage from year to year; and some of them are caused, at least in part, by the spraying of previous years, but they may also be caused by independent factors such as variations in climate and water supply, parasites and other natural enemies, pasturing, crop rotation and other practices.

The control of the weevil by these factors is not to be confused with the effect upon the spraying process itself. Growing conditions before, during, and after spraying time may greatly increase or decrease the effectiveness of the treatment. A distinction must also be drawn between alfalfa which is poor solely because of the weevil injury and that which is suffering from unfavorable soil, water and drainage conditions. There is a tendency on the part of some farmers to attribute poor crops to the weevil, even in fields which were unprofitable before the weevil came, and in which the severity of its attack is greatly increased by the unthrifty condition of the alfalfa. It is obvious that spraying alone will not make these fields productive.

On the other hand, many alfalfa growers are disappointed to find that the feeding marks on the first crop are not blotted out by the spray and feel tempted to cut the crop prematurely and before the full effect of the spraying is obtained. Cutting too soon after the spraying reduces its effect and may make it unprofitable. The benefits to the second crop from spraying are proportional to the number of larvæ killed on the first crop and this continues for at least a week after spraying and consequently this much time should elapse before the first crop is cut.

The question of ploughing up the alfalfa is often considered by farmers having their first year's experience with weevil injury. As for killing off the weevils, this radical method is not effective or advisable, because the weevils would live on volunteer alfalfa and other legumes and return to the field again as soon as it was reseeded. Crop rotation, however, may have indirect benefits both in decreasing the

number of weevils for any particular year and in producing alfalfa better able to withstand or outgrow the weevil attack.

Spraying was blamed for burning the timothy which grew with the alfalfa in many fields. Sometimes almost every blade of timothy in sprayed fields was found dried, curled up and covered with brown patches as though it had been burned, but as timothy similarly affected was found in fields which had not been sprayed it doubtless was attacked by some smut or rust.

TROUBLE EXPERIENCED WITH SPRAY OUTFITS

More trouble was experienced with the power sprayers than with the traction sprayer. The former, while they gave some engine trouble, caused delay more through defective parts of the engine, pump or boom breaking or working loose. A "breaker joint roller" on one of the power sprayers broke and could not be replaced in time for the sprayer to continue on the program as planned. The agitator chains broke occasionally or kept coming off, and the joints of the booms worked loose and leaked, due largely to deep threading followed by jolting over rough roads and furrowed fields. This latter defect was true also of the traction machine but to a less extent, probably because of its being much lighter. The nozzles clogged only occasionally, once in particular due to particles of paint and chips of wood inside the tank before it was properly cleaned, and at another time when a new lot of calcium arsenate was used which was not finely enough ground and which did not remain long enough in suspension. During the spraying the heavy power sprayers crushed down more alfalfa with their wide wheels than did the lighter traction machine, and because the booms were about half as long, they made about twice as many trips through the fields. At the time of cutting, the alfalfa in the tracks of the power sprayers had failed to straighten up fully in one or two fields and was mostly passed over by the mower whenever the latter happened to go in the same direction as the sprayer, that is in the direction in which the plants had been bent down. This condition was caused by the traction outfit to a slight extent wherever the ground was partly damp at the time of spraying.

CONCLUSION

The alfalfa weevil now occurs in several of the most important alfalfa districts in Nevada and will probably soon spread to the remaining sections. From the point of view of the harm it can or may do and of the indirect loss and annoyance to farmers, ranchers and business men through the quarantines imposed by certain States, it is one of the most destructive and important insect pests in the State. But there is no cause for alarm for, if the weevil is not controlled by natural means, it can be met by the control measures briefly described in this bulletin, especially by spraying. In addition to the control measures, the history of the spread of the weevil and an outline of its life history are given, followed by a more complete account of the demonstrations conducted in the Truckee Valley in 1924. The results of these demonstrations corroborate the work done in other States and in other years and show spraying to be an effective, practicable, and profitable method of control.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 109 | RENO, NEVADA | March, 1926

THE COMMON CHOKECHERRY

(*Prunus demissa*)

As a Plant Poisonous to Sheep and Cattle

By

C. E. FLEMING
Of the Department of Range Management

Assisted by

M. R. MILLER
Of the Department of Chemistry

and

DR. L. R. VAWTER
Of the Department of Veterinary Science

PRINTED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[71]

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

STAFF

Samuel B. Doten, M.A., Director .... Entomologist
F. L. Bixby, C.E. .... Irrigation
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)
George Hardman, M.S. .... Assistant in Irrigation
Charles E. Fleming, B.S.A. .... Range Management
Edward Records, V.M.D. .... Veterinary Science
Lyman R. Vawter, D.V.M. .... Assistant in Veterinary Science
M. R. Miller, B.S. .... Chemist
M. R. Schrock .... Fellow in Chemistry
F. B. Headley .... Farm Development
J. J. McElroy, B.S. .... Assistant in Farm Development
Robert Stewart, Ph.D. .... Collaborator in Soils
Matilda Marshall .... Statistician
Mary McGee .... Secretary to Veterinary Science
Martha R. Bruce .... Librarian and Secretary to Director
Grace Costello .... Secretary to Range Management

FOREWORD

This bulletin is based on information gathered from stockmen and upon long series of feeding experiments conducted by the Nevada Agricultural Experiment Station. The sheep and cattle were typical range animals, and every effort was made to have the conditions of the feeding tests conform as closely as possible to range conditions.

The results of the feeding tests are given in full detail and the bulletin necessarily contains some technical matter of greater interest to chemists and veterinarians than to owners of live stock. For the assistance of stockmen, therefore, a summary has been prepared and placed at the beginning. This will enable the busy owner of live stock to get a clear idea of chokecherry poisoning and the conditions under which it occurs, without being obliged to read the entire bulletin. To read it in full detail, however, will be well worth while.

S. B. DOTEN,
Director.

University of Nevada, March, 1926.

SUMMARY

(1) Under certain grazing conditions the common chokecherry of the mountain canyons is poisonous to sheep and cattle.

(2) It is a bush or small tree with dark-green glossy leaves. It bears masses of white flowers in long clusters in the spring, and a profusion of small purple cherries in similar clusters in the autumn.

(3) It grows in hillside thickets or in dense masses around moist spots on canyon slopes or as a tall shrub or small tree among willows, poplars and alders along the mountain streams.

(4) The leaves are poisonous to cattle and sheep from the end of April to the end of August. After August they become less dangerous and by October they have lost their poisonous properties.

(5) Cattle and sheep do not relish the chokecherry leaves and will not eat them unless driven to do so by hunger. Fatal poisoning occurs on ranges where drought and overstocking strip the range of grass and other forage and thus force the stock to eat the chokecherry.

(6) It does not take a very large quantity of the leaves to kill cattle. In experimental tests a fatal dose for a 500 pound animal is about one and one-half pounds of the leaves. A sheep may be killed by a little more than one-fourth pound.

(7) The fatal quantity must be eaten in one feeding; for the poison is thrown off rapidly by the animal's system; it does not accumulate nor does the animal become immune to the poison by eating small quantities of the leaves daily.

(8) Because the poison is thrown off so rapidly the animal may eat in the course of the day, in small lots, several times the fatal dose without being poisoned. This explains the fact that chokecherry bushes are often grazed without causing any losses of live stock.

(9) The poisoned animal becomes very uneasy, staggers, falls, goes into convulsions, breathes with increasing difficulty with eyes rolling and tongue hanging out. Then it becomes quiet, bloats and dies, usually within less than an hour after eating the leaves.

(10) The active poisonous principle of the chokecherry is hydrocyanic (prussic) acid. It is given off from certain chemical compounds in the crushed and moistened mass of leaves in the animal's stomach.

(11) The post-mortem conditions are those usually found in cases where death is due to suffocation. The lungs are heavy with blood, the mucous membranes of the mouth are blue. When the stomach is opened and the contents are stirred a strong order of prussic acid will be observed.

The Western Chokecherry (Prunus demissa)

THE COMMON CHOKECHERRY AS A PLANT POISONOUS TO SHEEP AND CATTLE

For several years in important grazing sections of Nevada, owners of cattle and sheep have suspected the common chokecherry of poisoning live stock that grazed too freely upon its leaves. Many inquiries for information on this topic have been received at the University. Feeding tests made at the Agricultural Experiment Station, supplemented by range observations, now show conclusively that the opinion of the stockmen is correct. In fact, the chokecherry can be held accountable for the death of many head of live stock where grazing conditions lead them to eat an excessive quantity of the leaves.

What This Bulletin Includes.

The studies made and reported upon in this bulletin cover the following topics: (1) The appearance of the chokecherry, and the places where it is found growing. (2) Its palatability to live stock. (3) The part of the plant that is poisonous. (4) The classes of live stock that are poisoned. (5) The time of year when it is most poisonous. (6) The conditions under which poisoning occurs. (7) Feeding experiments to find out whether the poison accumulates from day to day or whether it is rapidly eliminated. (8) Similar tests to learn whether the animal may become immune to the poison after repeated small feedings. (9) Long series of feeding tests of various quantities of the leaves to obtain accurate knowledge of the symptoms shown by the poisoned animals, seasonal variation in the poisonous properties of the plant, and the quantity of leaves required to kill cattle and sheep. (10) Possible remedies. (11) Chemical studies of the nature of the poisonous principle of the plant. (12) The post-mortem condition of poisoned animals.

Description of the Chokecherry.

The chokecherry belongs to the plum family. But it differs from other members of the family in the fact that the leaves appear before the flowers, and it does not come into full bloom until it is in almost full leaf.

The chokecherry ranges in height from a low-growing bush to a small tree. Sometimes it forms low thickets around damp places on dry hillsides, often it grows to greater height in the neighborhood of isolated mountain springs. Again it may reach a height of 25 feet or more and take on a tree-like form where it finds congenial conditions of soil and moisture along the streams.

The leaves usually begin to appear in April and the bush is in full leaf late in May. The leaves are oblong, dark green and glossy, rounded at the base and tapering at the tip. The full-grown leaf is about twice as long as it is broad; the margins are slightly toothed. Somewhere between the middle of May and the first few weeks in June the chokecherry bushes are fairly covered with a mass of white flowers. The individual flowers grow in long drooping clusters. At this season the shrub is very ornamental and it has in fact been brought under cultivation because of the beauty of the flowers and the foilage.

The flower clusters are replaced by drooping clusters of fruits, each

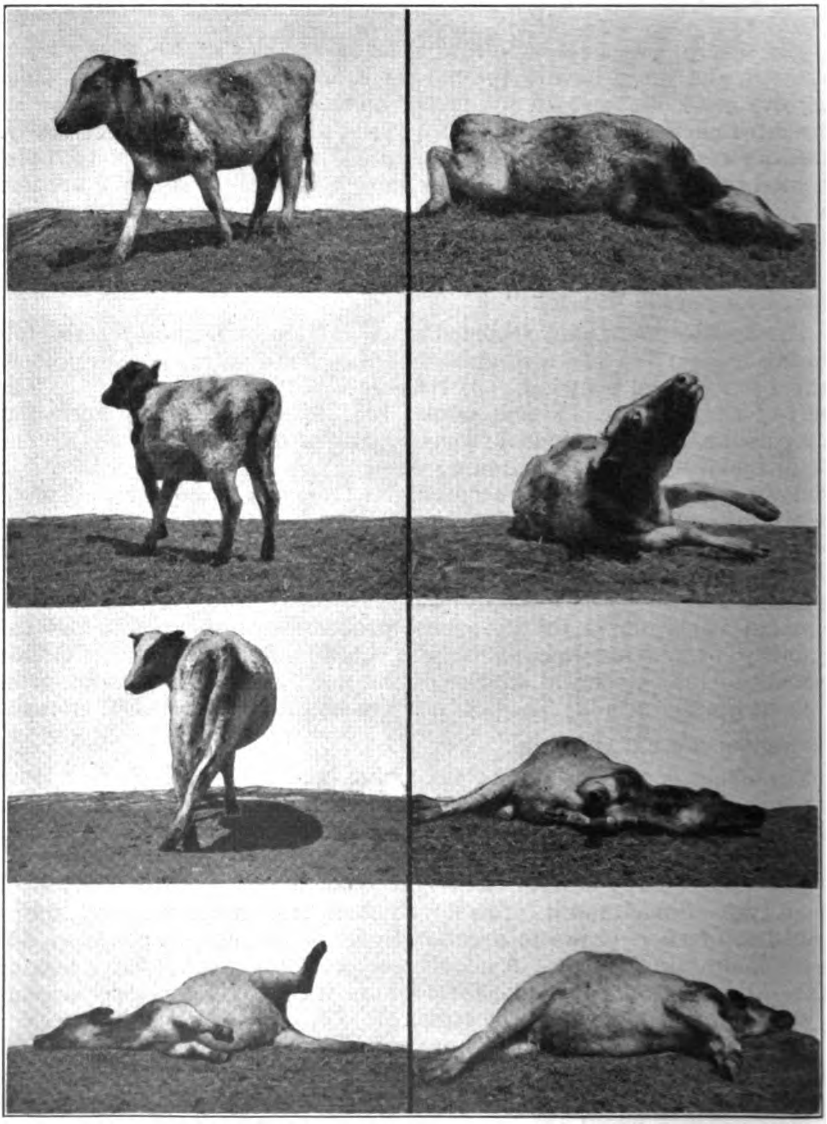


FIGURE 1. Stages of Chokecherry Poisoning. These photographs show the progress of poisoning from the first uneasiness to final bloating and death.

containing a pit like a small cherry stone. Late in the summer the color of the fruit changes from dark green to a ruddy purple which becomes almost black at the time of the first frost. When nearly ripe the red chokecherries are bitter and astringent; but later in the season, when they have turned deep purple and are almost ready to drop from the stem, the taste becomes more agreeable, and they are often gathered in considerable quantities and eaten or made into preserves.

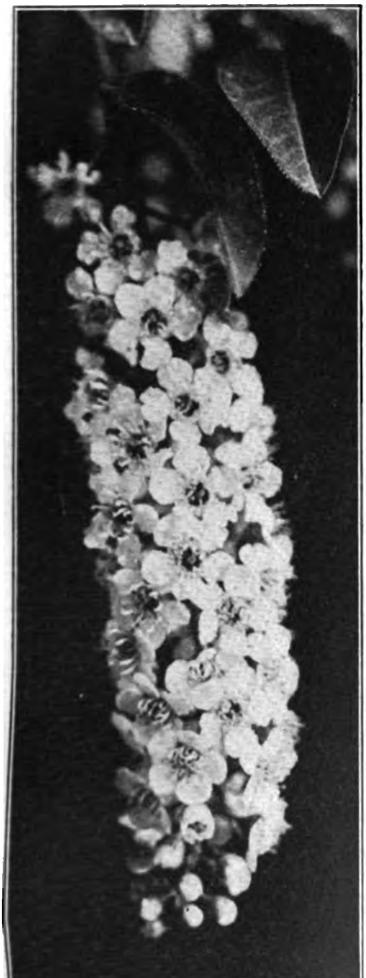


Figure 2. Flowers of the Chokecherry.

Regions Where the Chokecherry Grows.

The chokecherry is very widely distributed in western America. It is found in fact from parts of Canada south to New Mexico. In Nevada it usually grows in the neighborhood of small streams in the mountain canyons or in the foothill regions where there are springs or seepage. In all these places it may be found in small thickets of almost pure growth but it is more usually found growing with other woody plants such as alders, aspens, willows, dogwoods or other shrubby bushes such as the gooseberry and the wild currant.

The Palatability of Chokecherry Leaves.

The taste of the chokecherry leaves is not pleasant and does not appeal to range live stock; although some animals will eat the leaves more readily than others. In general they are not eaten by either cattle or sheep in dangerous quantities unless there is a distinct shortage of grass and other forage. The leaves cause all the live stock losses for which this plant is responsible.

Conditions Under Which Chokecherry Poisoning Takes Place.

Poisoning of range live stock usually takes place on overgrazed ranges where the animals are driven close to chokecherry thickets or along sheep trails where there is little else for the animal to eat. In times of drought and short range feed the danger of poisoning increases; for on ranges where there is only a scanty supply of grass and other range plants the animals become hungry enough to east fatal quantities of chokecherry or other plants that they ordinarily do not relish.

The Classes of Live Stock That Are Poisoned.

There is every reason to believe that the chokecherry is equally

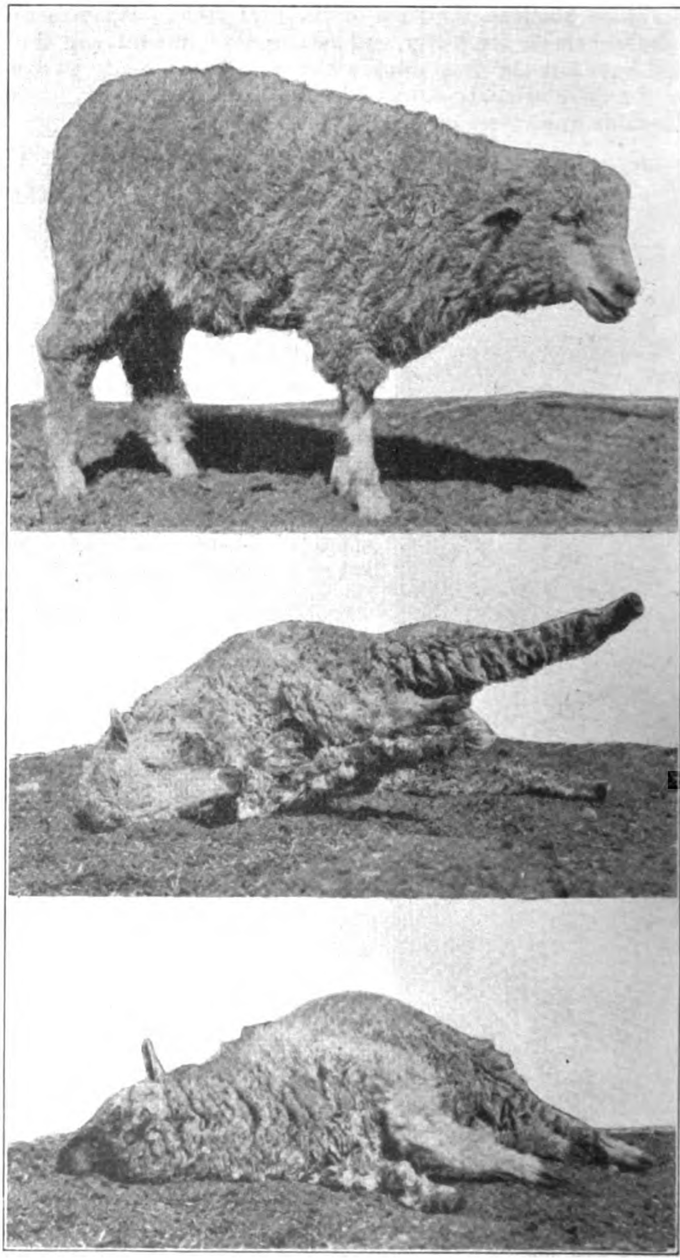


FIGURE 3. Three Stages of Chokecherry Poisoning in Sheep.

poisonous to cattle, sheep and horses, but under ordinary conditions the few horses on the range escape because of their habit of feeding on the higher hill ridges. The only losses actually reported which could be clearly traced to chokecherry were among sheep and cattle.

The Time of Year When the Chokecherry is Poisonous.

In late spring and early summer the leaves are more poisonous than they are later in the season. Late in the summer they begin to lose their poisonous properties; and in autumn they become practically harmless.

Live Stock Losses and Seasonal Changes in Poisonous Property of the Leaves.

Although the leaves are most deadly in spring and early summer, poisoning is not apt to occur then because the chokecherry is not relished by range animals and they can find enough grass and other

FIGURE 4. Chokecherry Branches Stripped of Leaves by Grazing Animals.

forage to supply their needs without eating a plant whose flavor is not agreeable. However, as the season advances, the more palatable forage on some of the ranges becomes so scarce that range live stock will then graze on many plants which they would ordinarily dislike and avoid. Under these conditions they may eat enough of the chokecherry at one time to cause death. Only a little later in the summer, however, the power of the leaves to kill falls off rapidly; and even with a short supply of better forage the danger of chokecherry poisoning may not be very great. The danger is always greatest on ranges where the grass and tender plants give out early and are almost gone at the time when the chokecherry leaves are most poisonous.

Symptoms of Poisoning in Cattle.

The following description of typical cases of chokecherry poisoning will give a clear idea of the whole series of symptoms from the first uneasiness until death:

Case No. 1

10:25 a. m. An animal weighing 402 pounds is fed 19 ounces of freshly gathered chokecherry leaves.

10:35 a. m. The animal is in distress and walks with an unsteady gait.

10:40 a. m. The animal staggers and totters and seems barely able to keep on its feet.

10:47 a. m. The animal falls and breathes with difficulty.

11:00 a. m. Respiration 14.

11:02 a. m. The eyes roll, the pupils are dilated. The animal breathes with increasing difficulty.

FIGURE 5. Chokecherry Bushes in Late Summer.

11:03 a. m. There are signs of bloating.

11:04 a. m. The animal groans, breathes slowly with great noise and difficulty. The mouth is wide open, the tongue hangs out, the muscles of the eyes twitch.

11:05 a. m. The pulse is 116. The first convulsions occur with a rapid running movement of the legs.

11:09 a. m. The convulsions continue with intervals of deathlike stillness during which the eyes are glassy and roll upward.

11:13 a.m. Respiration 10.

11:14 a. m. The convulsions cease. The animal becomes unconscious.

11:17 a. m. Death.

FIGURE 6. Leaves, Fruit, and Flowers of the Western Chokecherry.

Case No. 2

In this case an animal weighing 472 pounds was fed a little more than a pound of the green chokecherry leaves. Five minutes later it was uneasy and showed signs of distress. Within five minutes more there were pronounced symptoms of poisoning. The gait was unsteady, the breathing was labored and rapid and there was a strongly defined muscular twitching. Twenty minutes after the feeding the animal showed signs of recovery, although it still walked unsteadily and the muscular twitching continued. Twenty minutes later, however, it walked normally, drank water and ate hay and appeared to have fully recovered.

Case No. 3

9:00 a.m. An animal weighing 652 pounds is fed exactly two pounds of the green chokecherry leaves.

9:12 a.m. The animal is uneasy, walking unsteadily and breathing with difficulty.

9:20 a.m. The gait is tottering.

9:23 a.m. The animal falls.

9:25 a.m. The animal struggles, and there are almost continuous convulsive movements.

9:30 a.m. The convulsions are less frequent, the eyes are glassy and rolled upward, the pupils are large. The animal gasps and strangles, the mouth is wide open and the tongue hangs out.

9:40 a.m. The animal bloats and lies in death-like stillness.

9:45 a.m. Death.

From these descriptions of typical cases it is easy to see that the general course of fatal poisoning may be separated into four stages: (1) A period of uneasiness during which the poisoned animal will walk or run a short distance and then stop. This period of constant movement and rapid change of position is followed by the second stage. (2) In this stage respiration is difficult, muscular control is lost, the gait becomes unsteady and the animal totters and falls. (3) During the third stage extreme difficulty in breathing is shown by the wide open mouth with hanging tongue and very pronounced gasping and strangling. During this stage the poisoned animal struggles and its convulsions are severe and almost continuous. The eyes roll, the pupils are dilated. There is usually a muscular twitching of the lips, eyes, or flanks, the convulsions subside slowly and the animal lapses into almost complete insensibility. This is the beginning of the fourth stage which is brief. (4) The poisoned animal lies motionless on the ground with outstretched legs. At intervals there may be for a few seconds a feeble running movement of the legs. Breathing and heart action have almost ceased. Bloating begins slowly and gradually increases until death. The resipration ceases entirely, the pulse continues for a few moments, stops, and death follows.

Possible Remedies

The action of the poisonous principle of chokecherry leaves is very rapid; and the poison, hydrocyanic acid, is so deadly that on the range there is no opportunity for the use of any remedies.

It may be of some interest, however, to note the fact that in cases of hydrocyanic acid poisoning in farm animals some relief has been

obtained by the use of a drench made up of equal parts of sodium carbonate and iron sulphate. A leaflet[1] issued by the College of Agriculture of the University of California gives the following directions for preparing this drench:

> Bottle No. 1—Select a strong bottle of at least a quart capacity having a long neck suitable for use in drenching cattle. Place in this bottle one pint of water and one ounce of sodium carbonate. (Ordinary washing soda will do.) Keep tightly corked.
>
> Bottle No. 2—This should contain one-half ounce of iron

FIGURE 7. Suffocation is One of the Later Symptoms in Animals Poisoned by Chokecherry.

> sulphate (copperas) dissolved in a pint of water. Keep tightly corked.
>
> Directions for use of the antidote—When needed pour the contents of Bottle No. 2 into Bottle No. 1, shake and administer immediately. A cow should receive the entire quart of mixture. For a sheep one-half pint of the mixture would be sufficient. This antidote would be valuable also for Paris green or other arsenical poisoning. In case it seems desirable to have enough antidote on hand for several head of cattle, larger amounts of the solutions may be stored in demijohns or large glass carboys, but not in metal containers. When needed empty both reagents into a pail and administer to each animal from the mixture.

[1]"Precautions Against Poisoning by Johnson Grass and Other Sorghums."

The experiments made at the Nevada Station have shown that because of the paralytic action of the poison upon the respiratory tract and because of the violent convulsions which follow, it is a difficult matter to administer a drench without getting some of the fluid into the trachea or the windpipe and there seems to be little reason for expecting to cure poisoned animals by this means.

TABLE No. 1—CHOKECHERRY POISONING OF CATTLE

Tests Showing the Effect of Feeding the Leaves in Varying Quantities and at Different Seasons

Animal No.	Date fed	Amount fed, ounces	Live wgt., in pounds	Ounces fed per 100 lbs., live wgt.	Per cent fed of live wgt.	Severity of poisoning	Final result
1507	Apr. 24	17	440	3.86	.241	Very sick	Death
1502	Apr. 25	12	745	1.61	.100	No symptoms.	
1502	Apr. 27	16	745	2.14	.134	Slightly sick	Recovery
1415	Apr. 27	21	535	3.92	.245	Very sick	Recovery
1502	Apr. 28	17	745	2.28	.142	Slightly sick	Recovery
1502	Apr. 29	20	745	2.68	.167	Slightly sick	Recovery
1881	Apr. 30	15	472	3.17	.198	Very sick	Recovery
1883	Apr. 30	14	402	3.48	.218	Very sick	Recovery
2932	Apr. 30	16	388	4.12	.257	Very sick	Death
1502	Apr. 30	24	745	3.22	.201	Slightly sick	Recovery
1502	May 1	30	745	4.02	.252	Very sick	Recovery
1502	May 4	32	745	4.29	.268	Slightly sick	Recovery
1502	May 11	34	745	4.56	.285	Slightly sick	Recovery
1502	May 14	37	745	4.96	.310	No symptoms.	
1883	May 14	16	402	3.98	.248	No symptoms.	
1881	May 14	17	472	3.60	.225	No symptoms.	
1881	May 15	21	472	4.45	.278	Slightly sick	Recovery
69	May 18	17	404	4.20	.263	Very sick	Death
1883	May 18	19	402	4.72	.295	Very sick	Recovery
1625	May 18	30	628	4.77	.298	Very sick	Death
1881	May 18	17	472	3.60	.225	Slightly sick	Recovery
1881	May 19	18	472	3.81	.238	Very sick	Recovery
1502	May 22	28	745	3.75	.234	No symptoms.	
1411	May 22	18	390	4.61	.288	Very sick	Recovery
1108	May 23	21	428	4.90	.306	Very sick	Death
1502	May 27	30	745	4.02	.251	Slightly sick	Recovery
1411	May 27	19	390	4.87	.304	Very sick	Death
1502	June 8	32	745	4.29	.268	Slightly sick	Recovery
1401	June 27	35	725	4.82	.301	Very sick	Death
1209	June 28	36	750	4.80	.300	Very sick	Death
1463	July 1	16	850	1.88	.117	No symptoms.	
746	July 15	20	612	3.26	.204	Slightly sick	Recovery
1209	July 18	32	652	4.90	.306	Very sick	Death
1883	July 20	18	408	4.41	.275	Very sick	Death
364	July 20	27	633	4.26	.266	Very sick	Recovery
793	Aug. 4	40	801	4.99	.312	Very sick	Death
989	Aug. 4	20	488	4.09	.256	Slightly sick	Recovery
989	Aug. 10	24	488	4.91	.307	Slightly sick	Recovery
735	Aug. 16	26	507	5.12	.320	Slightly sick	Recovery
1589	Aug. 22	24	450	5.33	.333	Slightly sick	Recovery
698	Aug. 23	28	440	6.36	.397	Slightly sick	Recovery
763	Aug. 26	28	501	5.58	.349	Slightly sick	Recovery
1612	Aug. 26	50	481	10.39	.649	Very sick	Death
1000	Aug. 26	12	377	3.18	.198	No symptoms.	
1900	Aug. 27	24	377	6.36	.397	Slightly sick	Recovery
1432	Aug. 28	36	985	3.65	.228	Slightly sick	Recovery
1492	Sept. 5	38	985	3.85	.241	Slightly sick	Recovery
989	Sept. 10	24	488	4.91	.307	Slightly sick	Recovery
484	Oct. 2	80	587	13.60	.851	No symptoms.	
493	Oct. 2	62	479	12.90	.808	No symptoms.	
1307	Oct. 6	96	506	18.90	1.180	No symptoms.	
484	Oct. 15	76	591	12.80	.803	No symptoms.	
735	Oct. 29	16	515	3.10	.194	No symptoms.	
1432	Oct. 29	108	997	10.80	.677	No symptoms.	
735	Oct. 30	80	515	15.50	.970	No symptoms.	
612	Oct. 30	32	540	5.92	.370	No symptoms.	
612	Oct. 31	64	540	11.80	.740	No symptoms.	

Table No. 1 gives the results of 57 feeding experiments with cattle and brings out the following facts:

(1) The chokecherry leaves are most poisonous in the months of

spring and summer. From the end of April to the end of August they are deadly. After August they become less poisonous and in October they are practically harmless.

(2) In spring and early summer there is very little difference between the quantity of leaves that will make cattle sick and the quantity that will kill.

(3) A summary of the feeding tests made between April 24 and August 4 shows that with cattle, for each 100 pounds of live weight it took from 3.57 to 3.99 ounces of the leaves to cause poisoning and 4.60 ounces to cause death. That is, cattle are in danger in spring and summer when they eat in one feeding a quantity of leaves equivalent to one-fourth pound for each 100 pounds of their live weight.

(4) A study of the tests made between August 4 and September 10 will show that a greater quantity of leaves must be eaten at this time of year before symptoms of poisoning will be produced. In these experiments 5.11 ounces for each hundred pounds of live weight caused only slight poisoning, although a little earlier in the year 4.60 ounces caused death.

(5) The rapid loss of the poisonous property of the leaves in autumn is shown by the fact that after September 10, average feedings of 11.7 ounces per 100 pounds live weight caused no visible symptoms of poisoning.

Evidently, under range conditions, at any time in the grazing season still larger quantities will usually be required; for an animal on the range will not browse the chokecherry leaves as rapdly as it will eat them when they are gathered and fed all at one time in an experimental test.

TABLE No. 2—CHOKECHERRY POISONING OF CATTLE

Tests Showing a Rapid Elimination of Small Quantities of the Poison

Animal No.	Date fed	Hour fed	Amount fed, ounces	Live wgt., in pounds	Ounces fed per 100 lbs., live wgt.	Per cent fed of live wgt.	Severity of poisoning	Final result
3000	Aug. 21	8:20 a.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	9:20 a.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	10:40 a.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	11:30 a.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	12:55 p.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	2:00 p.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	3:00 p.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	4:20 p.	8	398	2.01	.125	No symptoms.	
3000	Aug. 21	4:50 p.	8	398	2.01	.125	Very sick	Recovery
5000	Aug. 18	9:00 a.	23	712	3.23	.201	Slightly sick	Recovery
5000	Aug. 20	8:00 a.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	9:00 a.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	10:00 a.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	11:00 a.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	12:05 p.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	1:00 p.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	2:00 p.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	3:00 p.	15	712	2.11	.132	No symptoms.	
5000	Aug. 20	3:30 p.	15	712	2.11	.132	Very sick	Recovery

The tests summarized in Table No. 2 show that:

(1) The poison is rapidly eliminated by the animal. It does not accumulate; and within a period of a few hours cattle may eat without injury an amount equal to many times the fatal dose, if the quantity eaten at any one time is fairly small.

This is well illustrated in the table; for within a period of 8½ hours

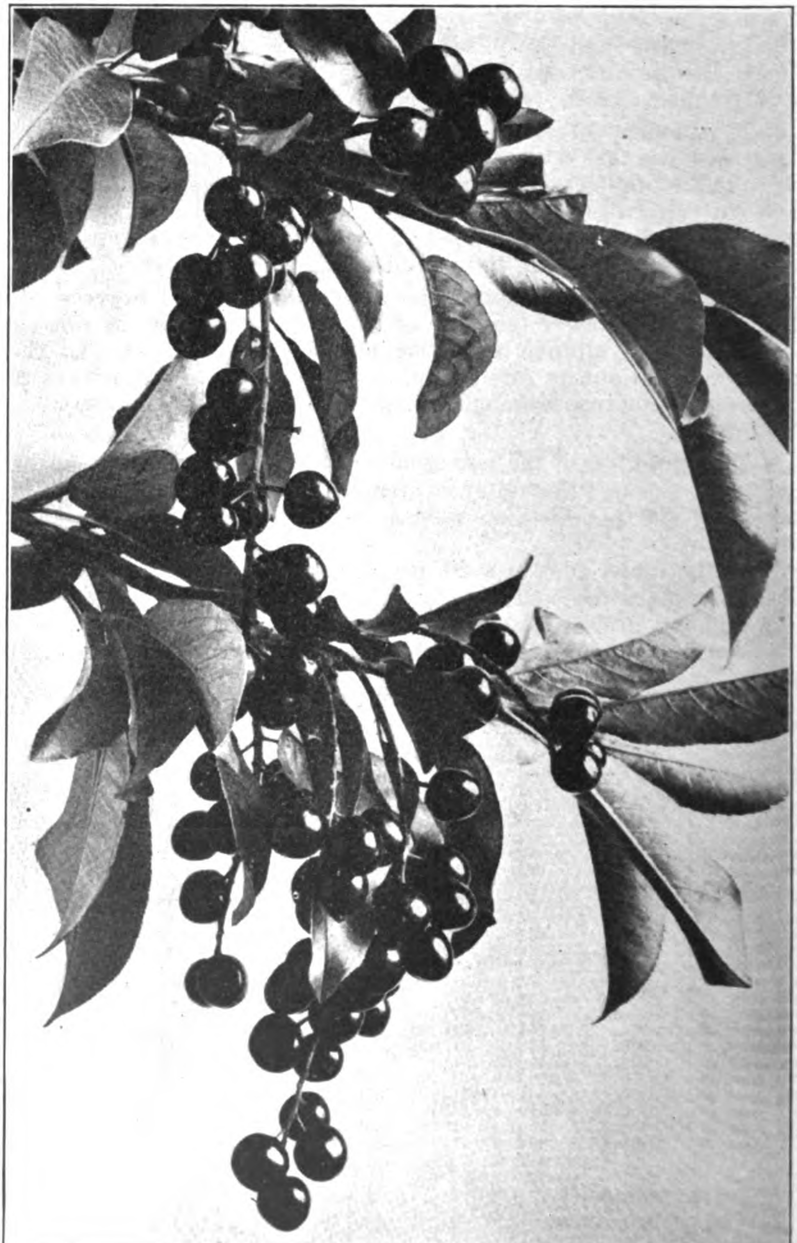


FIGURE 8. Ripe Chokecherries in October. The leaves are turning yellow and the plant is no longer dangerous.

Animal No. 3000 was fed in half-pound doses at hourly intervals a total of 4½ pounds of the leaves; and within 7½ hours Animal No. 5000 was fed almost 8½ pounds. In both instances the total quantity eaten was several times greater than the fatal dose, which should be a little more than a pound for the lighter experimental animal and almost exactly two pounds for the heavier one.

(2) Fed at intervals of an hour apart, half-pound doses had no effect upon the smaller animal nor doses of nearly a pound upon the larger one. When the interval was shortened to one-half hour severe symptoms followed.

These tests are very instructive. They show clearly why it is that on the range the chokecherry bushes are grazed without causing losses of live stock; for under ordinary conditions, although the grazing animls eat from time to time some of the leaves usually mixed with other forage, they do not eat at any one time a quantity great enough to be harmful.

TABLE No. 3—CHOKECHERRY POISONING OF CATTLE

Tests Showing that Cattle Do Not Become Tolerant of the Poison Nor Acquire Any Immunity to it by Eating Small Quantities of the Leaves at a Time for Several Days

Animal No.	Date fed	Amount fed. ounces	Live wgt., in pounds	Ounces fed per 100 lbs., live wgt.	Per cent fed of live wgt.	Severity of poisoning	Final result
1588	Aug. 8	4	401	.997	.062	No symptoms.	
1588	Aug. 9	4	401	.997	.062	No symptoms.	
1588	Aug. 10	4	401	.997	.062	No symptoms.	
1588	Aug. 11	8	401	1.990	.124	No symptoms.	
1588	Aug. 12	8	401	1.990	.124	No symptoms.	
1588	Aug. 13	8	401	1.990	.124	No symptoms.	
1588	Aug. 14	12	401	2.990	.187	No symptoms.	
1588	Aug. 15	12	401	2.990	.187	No symptoms.	
1588	Aug. 16	12	401	2.990	.187	No symptoms.	
1588	Aug. 17	12	401	2.990	.187	No symptoms.	
1588	Aug. 18	16	401	3.990	.249	Slightly sick	Recovery
1588	Aug. 19	20	401	4.980	.311	Very sick	Recovery
1587	Aug. 6	4	405	.987	.061	No symptoms.	
1587	Aug. 7	4	405	.987	.061	No symptoms.	
1587	Aug. 8	4	405	.987	.061	No symptoms.	
1587	Aug. 9	4	405	.987	.061	No symptoms.	
1587	Aug. 10	4	405	.987	.061	No symptoms.	
1587	Aug. 11	8	405	1.970	.123	No symptoms.	
1587	Aug. 12	8	405	1.970	.123	Slightly sick	Recovery
1587	Aug. 13	8	405	1.970	.123	No symptoms.	
1587	Aug. 14	12	405	2.960	.185	No symptoms.	
1587	Aug. 15	12	405	2.960	.185	No symptoms.	
1587	Aug. 16	12	405	2.960	.185	No symptoms.	
1587	Aug. 17	12	405	2.960	.185	No symptoms.	
1587	Aug. 18	16	405	3.950	.246	No symptoms.	
1587	Aug. 19	20	405	4.930	.308	Very sick	Recovery
1587	Aug. 20	20	405	4.930	.308	Very sick	Death
4000	July 18	12	510	2.350	.147	Very sick	Recovery
4000	July 19	12	504	2.380	.148	Slightly sick	Recovery
4000	July 20	12	507	2.360	.147	No symptoms.	
4000	July 21	12	508	2.360	.147	No symptoms.	
4000	July 24	12	520	2.300	.144	Very sick	Recovery
4000	Aug. 4	12	515	2.330	.145	No symptoms.	
4000	Aug. 5	16	510	3.130	.196	No symptoms.	
4000	Aug. 6	20	512	3.900	.244	Very sick	Death

The feeding tests recorded in Table 3 show clearly that daily experimental feeding of small quantities of the leaves fail to build up any tolerance of the poison on the part of the animal.

For ten successive days Animal No. 1588, weight 401 pounds, was fed chokecherry leaves in doses that were gradually increased in quantity

from one-fourth pound to three-fourths pound. No symptoms of poisoning were detected. On the eleventh day a pound was given the animal; and some symptoms were observed. On the twelfth day 1¼ pounds caused such severe poisoning that it was evident that any larger dose would be fatal.

That is, after being fed small quantities of the leaves for several days, the animal nearly died when fed approximately the same number of ounces per hundred pounds live weight that had killed other cattle at about this time of year. Apparently this animal had not acquired any immunity to the poison as a result of having been fed 7½ pounds of the leaves during the period of twelve days.

TABLE No. 4—CHOKECHERRY POISONING OF SHEEP

Tests Showing the Effect of Feeding the Leaves in Varying Quantities and at Different Seasons

Animal No.	Date fed	Amount fed, ounces	Live wgt., in pounds	Ounces fed per 100 lbs., live wgt.	Per cent fed of live wgt.	Severity of poisoning	Final result
2	Apr. 24	3.0	67	4.47	.279	Very sick	Death
6	Apr. 24	2.5	82	3.04	.190	Slightly sick	Recovery
5	Apr. 24	2.5	75	3.33	.208	Very sick	Recovery
10	May 6	2.5	76	3.28	.205	Very sick	Recovery
9	May 6	3.0	69	4.34	.271	Very sick	Death
11	May 6	2.5	85	2.94	.183	Slightly sick	Recovery
8	May 27	2.5	59	4.23	.264	Very sick	Death
14	May 28	2.5	81	3.08	.192	Slightly sick	Recovery
16	May 29	2.5	79	3.16	.197	Slightly sick	Recovery
20	May 30	3.0	84	3.57	.223	Very sick	Recovery
31	June 1	3.0	80	3.75	.234	Very sick	Death
100	June 12	2.0	62	3.22	.201	Slightly sick	Recovery
200	June 26	3.0	99	3.03	.189	Slightly sick	Recovery
68	June 26	3.5	87	4.02	.251	Very sick	Death
300	July 3	3.0	91	3.29	.206	Slightly sick	Recovery
350	July 8	2.0	62	3.22	.201	Slightly sick	Recovery
300	July 15	3.0	91	3.29	.206	Slightly sick	Recovery
300	July 15	3.5	91	3.84	.240	Very sick	Recovery
301	July 15	3.5	87	4.02	.251	Very sick	Death
400	July 16	2.0	71	2.81	.176	No symptoms.	
425	July 19	3.0	61	4.91	.307	Very sick	Death
450	July 19	2.0	85	2.35	.147	No symptoms.	
475	July 20	2.0	73	2.73	.171	No symptoms.	
500	July 21	3.0	66	4.54	.284	Very sick	Death
525	July 25	3.0	98	3.06	.191	No symptoms.	
550	July 29	3.0	97	3.09	.193	No symptoms.	
575	July 29	3.0	64	4.68	.292	Very sick	Death
10	Aug. 5	3.0	75	4.00	.250	Very sick	Death
20	Aug. 6	3.0	71	4.22	.264	Very sick	Death
30	Aug. 16	2.0	59	3.38	.211	Slightly sick	Recovery
953	Aug. 19	3.0	65	4.61	.288	Very sick	Death
959	Aug. 21	3.0	120	2.50	.156	No symptoms.	
40	Aug. 22	5.0	153	3.26	.204	Slightly sick	Recovery
1676	Aug. 25	3.0	83	3.61	.226	Slightly sick	Recovery
1698	Aug. 25	4.0	89	4.49	.280	Very sick	Death
1676	Aug. 26	3.0	83	3.61	.226	Very sick	Death
50	Aug. 27	3.0	87	3.45	.215	Slightly sick	Recovery
659	Aug. 28	7.0	150	4.66	.291	Very sick	Death
367	Sept. 3	3.0	84	3.57	.223	Slightly sick	Recovery
26	Sept. 9	2.0	63	3.17	.198	No symptoms.	
26	Sept. 21	1.0	65	1.53	.096	No symptoms.	
29	Sept. 21	1.0	83	1.20	.075	No symptoms.	
41	Sept. 21	3.0	92	3.26	.203	No symptoms.	
28	Sept. 21	3.0	87	3.44	.215	Slightly sick	Recovery
26	Sept. 25	2.0	63	3.17	.198	No symptoms.	
29	Sept. 25	5.0	83	6.02	.376	Slightly sick	Recovery
45	Sept. 29	5.0	72	6.94	.434	No symptoms.	
978	Oct. 3	6.0	169	3.55	.222	No symptoms.	
979	Oct. 6	10.0	158	6.33	.422	No symptoms.	
979	Oct. 7	16.0	158	10.12	.675	No symptoms.	
979	Oct. 8	24.0	158	15.19	1.013	No symptoms.	
60	Oct. 15	5.0	68	7.35	.459	No symptoms.	
44	Oct. 30	5.0	108	4.62	.289	No symptoms.	
37	Oct. 30	8.0	108	7.40	.463	No symptoms.	
26	Nov. 4	3.0	75	4.00	.250	No symptoms.	
45	Nov. 4	8.0	72	11.11	.694	No symptoms.	
65	Nov. 6	5.0	69	7.24	.452	No symptoms.	
45	Nov. 8	3.0	72	4.16	.260	No symptoms.	

The test was repeated with a second animal of about the same weight. The dose was increased as before from one-fourth to three-fourths pound through a period of twelve days. On the thirteenth day it was increased to one pound without causing symptoms of poisoning. On the fourteenth day, however, a feeding of 1¼ pounds caused severe poisoning, the animal being barely able to stand on its feet. On the fifteenth day the same quantity caused death.

Still another test, with a somewhat heavier animal, showed that a feeding which is dangerously large may cause severe illness one day without causing any symptoms at all on another day. On July 18, Animal No. 4000 was severely poisoned by a feeding of three-fourths pound of the leaves. The same dose on the following day caused only mild symptoms. On July 20 and 21 no detectable symptoms were caused by feeding the same quantity of leaves. On July 24 the animal was again fed the same quantity and was poisoned so violently that it barely escaped death. On August 4 the same dose, three-fourths pound of leaves, caused no visible signs of poisoning; and on the following day a full pound was fed without result. The next day, when a test was made with 1¼ pounds, a quantity still a little below the usual fatal dose for an animal of 500 pounds, violent poisoning and death followed.

Evidently cattle that are feeding on the open range do not develop any tolerance or power to endure the poison of the chokecherry by eating small quantities of the leaves from time to time for a considerable period. They are almost certain to die whenever they eat enough of the leaves at once to carry a fatal dose of the poison.

A brief analysis of the tests summarized in Table No. 4 will show that:

(1) After a sheep has become severely poisoned by chokecherry there is little prospect of its recovery; for out of 19 such cases 15 died.

(2) The leaves may cause fatal poisoning from about the first of May to the first of September. Under range conditions this is only an approximation; because the length of the period when the plant is dangerous changes with altitude, latitude and seasonal climatic conditions.

(3) When an average is taken of all the feeding tests with sheep made between April 24 and August 28, we find that for each 100 pounds of the animal's live weight, it took 3.23 ounces of the leaves to cause slight symptoms of poisoning, 3.50 ounces to cause severe symptoms followed by recovery, and 4.30 ounces to cause death.

(4) On August 25 a comparison was made of mature leaves that had been formed in the spring with new leaves on shoots still growing rapidly. Three ounces of the old leaves fed to sheep No. 1676 failed to cause symptoms; but three ounces of the new ones from the growing shoots caused death. These effects correspond closely to the percentages of hydrocyanic acid in new leaves and old shown by chemical analysis.

(5) In the tests made later than August 28 it was evident that the leaves had lost most of their poisonous properties; for only two sheep showed symptoms of poisoning and the effect in each case was slight. The other feedings made in the autumn caused no symptoms even though the animal ate leaves at the rate of nearly a pound, 15.19 ounces, per hundred pounds of live weight.

SECTION II (Technical)

The material presented in this section is not intended especially for use by stockmen; it is, however, of considerable interest to chemists and veterinarians and has been included in this bulletin for the sake of keeping together in one publication all information growing out of the work of the Station upon this subject. It consists of two parts as follows:

(1) THE ACTIVE POISONOUS PRINCIPLE OF THE CHOKECHERRY (*Prunus demissa*). By M. R. Miller, Chemist of the Nevada Agricultural Experiment Station.

(2) POST-MORTEM CONDITIONS IN CASES OF CHOKECHERRY POISONING. By Dr. Lyman R. Vawter, Assistant Veterinarian, Nevada Agricultural Experiment Station.

1. THE ACTIVE PRINCIPLE OF PRUNUS DEMISSA

The leaves of *Prunus demissa* yield hydrocyanic acid. In order that the manner in which hydrocyanic acid becomes capable of being freed from the leaves and producing toxic reactions when eaten by animals, a short discussion of its manner of occurrence will be given. The mechanism of hydrocyanic acid evolution from the leaves is similar to that of the bitter almond, and well it may be, on account of the botanical relations of the two plants. Hydrocyanic acid, or prussic acid, HCN, is a widespread constituent of many species of plants, occurring in various parts of the plant, the leaves, bark and fruits. Almost invariably it has been found to occur, not in the free state but in combination with sugars and other organic compounds. Such naturally occurring hydrocyanic acid combinations with sugar, and other compounds are called glucosides and from these the sugar, hydrocyanic acid and other substance may be separated or split off through the action of suitable reagents.

The historically important glucoside of this type is amygdalin, occurring in the bitter almond. It was first purified in 1830. When the presence of hydrocyanic acid began to be noted in other plants there was a long period during which it was concluded that amygdalin was present. However, it has been shown that amygdalin is but one of a series of glucosides, called cyanogenetic glucosides. Many of them have been purified and studied. Certain of them are isomerides of amygdalin, while others are of different composition entirely.

The hydrocyanic acid may be liberated in two ways from the cyanogenetic glucosides. Acids can cause hydrolysis in which the components are split off. However, the cyanogenetic glucosides are more commonly broken up and the hydrocyanic acid set free through the action of certain nitrogenous substances called enzymes which occur in the tissue of the same plant. The enzyme accompanying amygdalin in the bitter almond is called emulsin (this enzyme really contains two enzymes, amygdalase and prunase, which act in turn on amygdalin) and its action on the glucoside is occasioned by simply crushing the almond with water, whereby the hydrocyanic acid is liberated. In addition to the hydrocyanic acid there is also set free sugar and benzaldehyde. The latter has the characteristic odor of the bitter almond.

The glucoside in the leaves of *Prunus demissa* is similar to amygdalin in that it is broken up by its accompanying enzyme and furnishes hydrocyanic acid, sugar and benzaldehyde. In order that the hydrocyanic acid be made available in the leaves it is only necessary that the tissues be broken so that the enzyme may act upon the glucoside and that moisture be present to enable the reaction to proceed. When green leaves are crushed there is enough natural moisture in the juices for the purpose. If the dried leaves are finely crushed there will be little or no evolution of hydrocyanic acid until moisture is supplied, as by wetting with water.

The glucoside may be prepared in the pure crystalline condition and has been prepared in the form of a thick sirup by the writer. It does not crystallize except with the greatest difficulty and the writer has never been fortunate in having it do so.

The amounts of hydrocyanic acid found in the leaves at various stages of growth are reported in the following table. The determinations were made by the method to be described. These results are probably lower than the true content of hydrocyanic acid but they are consistent and will serve at least for a comparison of quantities available in the leaves from different sources. The results also check fairly well with those obtained in the feeding experiments described and serve in most cases to explain the quantities used to produce poisoning:

Hydrocyanic Acid in Leaves of Prunus Demissa

Collected	Source	Hydrocyanic acid %	Moisture %
June 25, 1924	Fruit-bearing wood	.210	64.80
June 25, 1924	Fruit-bearing wood	.220	29.09
August 9, 1924	Fruit-bearing wood	.205	(Fresh)
August 15, 1924	Fruit-bearing wood	.180	(Fresh)
August 22, 1924	New shoots or suckers	.190	(Fresh)
August 25, 1924	Fruit-bearing wood	.120	(Fresh)
October 7, 1924	Frosted and colored	.071	(Fresh)
April 24, 1925	New shoots or suckers	.252	(Fresh)
May 1, 1925	New shoots or suckers	.278	(Fresh)
May 1, 1925	Fruit-bearing wood	.216	(Fresh)
May 16, 1925	New wood, no flowers	.204	64.20
May 16, 1925	New wood, no flowers	.160	33.80
May 18, 1925	Fruit-bearing wood	.351	(Fresh)
May 18, 1925	Fruit-bearing wood, leaves only	.368	(Fresh)
May 19, 1925	Fruit-bearing wood	.288	(Fresh)

The analyses are on material as stripped from the trees and include the twigs as they break from the branches. In the case of one of the samples, that of May 18, 1925, the leaves were carefully separated from the twigs and the determination was made on the leaves only. Two of the samples (June 25 and May 16), after determinations were made on the fresh material, were allowed to wilt in the laboratory. Moisture determinations were made on the fresh and wilted leaves as well as the hydrocyanic acid estimation. The results show the loss in moisture and in one case less and in the other a slightly higher percentage of hydrocyanic acid. If one corrects for the loss of moisture it will be found that hydrocyanic acid has been lost along with the moisture. This loss does not finally include all the hydrocyanic acid available as drying proceeds as may be shown in the case of completely air-dried leaves. Even when air-dried and reduced to a powder the leaves retain their capability of evolution of the poison for a long time after being moistened. Leaves have been found to yield 0.138% of hydrocyanic acid after having been air-dried and ground for over five years. This air-dried material contained about 7% of moisture. These results show that contrary to a popular supposition the leaves do not become more toxic on account of increase in hydrocyanic acid when they are allowed to wilt.

The leaves from the new shoots are shown to yield more of the poison than those from the old wood. There is a decline in the quantity as the season progresses until frost time. Both these conditions have been checked by observations on the quantity necessary to produce poisoning when fed.

It is also interesting to note in this connection that this had also been observed in other cyanogenetic plants. Ravena (Czapek III, 217), has shown that in sorghum, which contains a cyanogenetic glucoside in the

leaves, there was an increase in the hydrocyanic acid found in the leaves even from morning to afternoon. The hydrocyanic acid content is connected with the physiological activity of the plant, and, of the above samples, those collected May 18 and May 19 on bright and rainy days, respectively, show a difference in the hydrocyanic acid content.

Method Used for the Estimation of Hydrocyanic Acid

The method used for the above estimations is a follows: A 50 gram sample of the leaves ground in the food chopper was moistened with enough water to cover and allowed to macerate from 20 to 30 minutes in the distillation flask connected to condenser and receiver. The receiver contained 10–15 c.c. of 5% sodium hydroxide into which the delivery tube dipped. After the maceration period the liberated hydrocyanic acid was swept out by a current of steam.

The distillate was collected until it amounted to about 500 c.c. when the distillation was stopped. The distillate was then made to a definite volume and an aliquot titrated with N/50 silver nitrate solution, using 10–15 drops of 10% potassium iodide as an indicator. The method, while it gives consistent results, does not give the absolute amount of hydrocyanic acid present in the leaves. A short discussion of the various steps in the determination is given below and the sources of error noted:

Grinding. More finely ground leaves should give a slightly higher hydrocyanic acid content. The more the cells are crushed and ruptured, the greater the likelihood of all of the glucoside being broken up by the enzyme.

Maceration. A maceration period of 20–30 minutes is sufficient to give consistent results. A shorter period is apt to result in a lower yield while there is but little to be gained in a longer maceration. In fact, with longer periods of maceration than are necessary to liberate all the hydrocyanic acid, it is possible that the results may be lower on account of combination of the liberated hydrocyanic acid with sugars, aldehydes, etc. Even during the period used in this work there must have been a certain loss of hydrocyanic acid through combination with the liberated benzaldehyde.

Distillation. Steam distillation will remove all the liberated hydrocyanic acid. In addition it removes the benzaldehyde. These have opportunity to combine in the distillate. That they must combine to a certain extent is demonstrated by the following experiment: Mixtures of definite concentrations of hydrocyanic acid with a saturated solution of benzaldehyde and titrated with silver nitrate solution gave lower results with increasing amounts of benzaldehyde present. This will result in a lower figure for the per cent of hydrocyanic acid found than would result if the benzaldehyde were not present.

Titration. Experiments made in titrating definite quantities of alkali cyanide in alkaline solutions with various amounts of sodium hydroxide in excess showed that the quantity of hydroxide has but little influence.

The use of a solution of potassium iodide gives a more definite and accurate end-point than when dependence is placed only on the formation of the insoluble silver cyanide. With such dilute solutions as are

sometimes titrated the end of the reaction may be passed by several cubic centimeters of silver solution before a perceptible turbidity results.

2. POST-MORTEM SYMPTOMS OF PRUNUS DEMISSA

Rigor mortis was quickly established. A pronounced cyanosis of the mucous membranes of the mouth and eye was observed. Subcutaneous venous engorgement was well marked. Cattle dead as result of feeding upon *Prunus demissa* exhibited a pronounced anemia of certain groups of skeletal muscles. This change was not constantly confined to any muscle group. It was found in the muscles of the neck, shoulder, loins and thigh. Only one group of muscles was found to be affected in any one animal. This post-mortem change has not been observed in experimental or field work with other poisonous plants.

The intestines were always found to be of a very light pale color, indicating a practically bloodless condition of this part of the abdominal viscera; the mucous membrane did not manifest any pathological change.

The mucous membrane of the abomasum mainfested the characteristic chestnut brown color of cyanide poisoning. In addition the odor of prussic acid was readily recognized. No change was noted in the other three compartments of the stomach, but the odor of prussic acid was easily detected particularly in the contents of the reticulum.

Manual agitation of the contents often aids in quick detection of this odor. Examination for prussic acid odor must be made immeditely following exposure of the stomach contents to the open air.

The lungs uniformly manifested a very dark color due to passive congestion; they were greatly increased in weight and slightly oedematous.

The heart manifested a few scattered subepicardial petechiae which did not differ in any respect from those observed in autopsies on animals dead as result of poisoning by other poisonous plants or certain infectious diseases.

The mucous membrane of the trachea was greatly congested particularly in the lower two-thirds. This congestion was continuous into the bronchi and bronchioles.

No characteristic change was observed in the body lymphatic glands. The mediastinal and bronchial lymph glands were uniformly congested and a few cortical hemorrhages were occasionally observed.

Summary

When it is known that shortly before death the animals have consumed the green leaves of the chokecherry, the post-mortem findings outlined above are in our opinion sufficient evidence for a diagnosis of chokecherry poisoning.

This form of fatal poisoning is ushered in by a brief period of stimulation which is followed in a few minutes by incoordination of gait, prostration and respiratory disturbances. Death is due to the depressant effect of the prussic acid upon the respiratory and cardiac centers of the brain.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 110 RENO, NEVADA January, 1928

THE POISONING OF SHEEP ON MOUNTAIN GRAZING RANGES IN NEVADA

By the

WESTERN CHOKECHERRY

(*Prunus demissa*)

By

C. E. FLEMING
Of the Department of Range Management

Assisted by

DR. ROBERT DILL
Inspector in Charge of Nevada Sheep Commission

PRINTED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[54]

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

OFFICERS

Walter E. Clark, Ph.D. .... President of the University
Charles H. Gorman .... Comptroller
George H. Taylor .... Secretary Emeritus
Carolyn Beckwith .... Secretary

STAFF

Samuel B. Doten, M.A., Director .... Entomologist
Charles E. Fleming, B.S.A. .... Range Management
Edward Records, V.M.D. .... Veterinary Science
George Hardman, M.S. .... Assistant in Irrigation
M. R. Miller, M.S. .... Chemist
Lyman R. Vawter, D.V.M. .... Assistant in Veterinary Science
F. L. Bixby, C.E. .... Irrigation
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)
Robert Stewart, Ph.D. .... Soil Fertility
Chester Brennen, B.A. .... Economist in Range Management
F. B. Headley .... Farm Development
R. M. Clawson, B.S. .... Assistant in Farm Development
McKean Carter, A.B. .... Fellow in Chemistry
Andrew Young .... Assistant in Range Management
Matilda Marshall .... Specialist in Farm Cost Studies
Louise Lewers .... Secretary to Veterinary Science
Martha R. Bruce .... Illustrator and Secretary to Director
Grace Costello .... Librarian and Secretary

FOREWORD

This bulletin is a supplement to Bulletin No. 109 of the Nevada Station, "The Common Chokecherry (*Prunus demissa*), as a Plant Poisonous to Sheep and Cattle." Bulletin 109 presented information gained by feeding the plant to animals under experiment at the Station. The present bulletin is based upon field observations of chokecherry poisoning of sheep in the mountain country.

It throws light upon the peculiar cases of slow poisoning of sheep by chokecherry that occur on grazing ranges remote from water. In these cases the leaves are held in the first stomach with other partly-dry feed until the animal drinks. The poison is then liberated and the animal may die promptly; although in many instances the poison is even then liberated so gradually that the sheep may show symptoms of poisoning for many hours or perhaps for an entire day before death or recovery.

The Station gratefully acknowledges the assistance given by Doctor Robert Dill of the Nevada Sheep Commission in the study of the slow form of chokecherry poisoning on Nevada sheep ranges.

SUMMARY

(1) Mysterious losses of sheep on certain grazing ranges in eastern Nevada were investigated in the summer of 1927 by C. E. Fleming of the Nevada Agricultural Experiment Station and Doctor Robert Dill of the Nevada Sheep Commission.

(2) Herders in charge of the animals believed that the sheep had been poisoned by drinking from mountain streams; for the symptoms of poisoning followed promptly after drinking.

(3) Studies of the poisoned animals and post-mortem examinations showed that death was due to a form of chokecherry poisoning that had not previously been observed.

(4) Several hours before drinking the poisoned animals had eaten fatal quantities of chokecherry along with other half-dry leaves and browse, but there was not moisture enough in the stomach to set the poison free from the leaves.

(5) As soon as the animals drank, the added moisture caused the liberation of the poison and the immediate poisoning of the sheep.

(6) In some such cases the sheep died promptly, in other instances even after the animals drank water the poison was liberated rather slowly, and symptoms of poisoning were present for hours, even for a day or more.

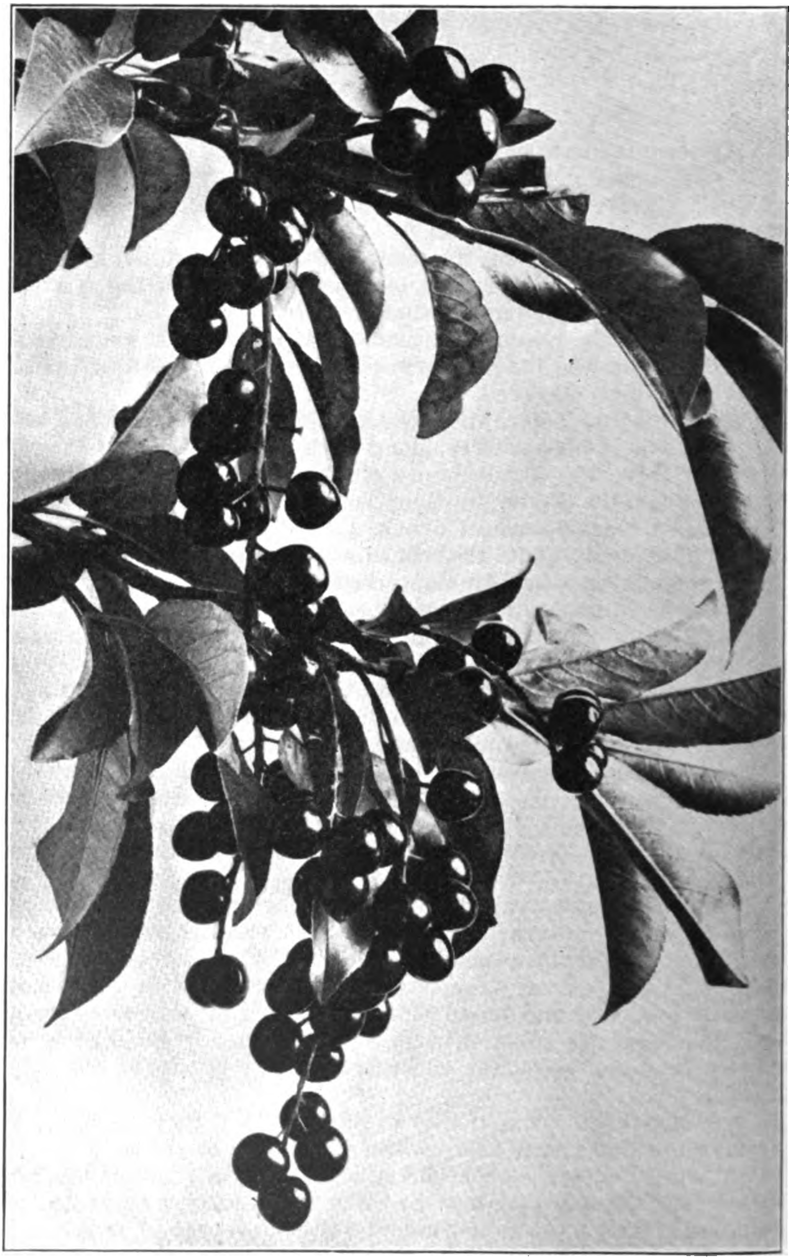
(7) Like many other forms of plant poisoning of both sheep and cattle this form of chokecherry poisoning is primarily due to the dried and overgrazed condition of the range.

This fact again emphasizes the need of an intelligent system of administration of sheep and cattle ranges on the public domain that will result in their being grazed only at the right season and in the right manner and by a number of animals small enough to prevent overgrazing.

(8) There is no known remedy for chokecherry poisoning. Careful herding of sheep on grazing ranges where chokecherry grows will diminish the danger of poisoning. Sheep should not be allowed to "shade up" in chokecherry thickets in the heat of the day, nor should they be driven hard and hazed along by dogs and herders on ranges where chokecherry is abundant. Sheep are normally inclined to pick their own food and to let the chokecherry alone or else to eat only a little of it.

They do not like it; but, if they are driven hard they are obliged to eat everything that comes along without a chance to choose.

(9) In late summer the chokecherry leaves lose their poisonous properties. In the autumn they may be eaten in quantity without harm to the sheep and are, in fact, considered valuable forage at that time of year.



Ripe Chokecherries in October. The leaves are turning yellow and the plant is no longer dangerous.

CHOKECHERRY POISONING OF SHEEP

In the course of the last few years the common western chokecherry has come to be recognized as one of the plants frequently responsible for the death of range sheep, more particularly mature ewes and yearlings rather than lambs.

The Importance of the Chokecherry as a Range Plant Poisonous to Sheep.

The increasing importance of the chokecherry as a plant poisonous to both sheep and cattle is probably due mainly to the recent years of drought which limited or restricted to a very marked degree the normal yearly production of nutritious grasses, weeds, and browse. This shortage of feed caused ranges in certain grazing areas to become severely overgrazed. The badly overgrazed ranges consequently have not produced and at the present time are not producing sufficient forage to satisfy the sheep completely with plants that they prefer and upon which they have in the past contented themselves. This scanty production of valuable forage plants is now forcing the sheep to eat plants which in earlier years, when range conditions were more favorable, were not eaten to any great extent because they did not appeal to the appetite of the sheep.

The chokecherry is one of the plants that are not grazed by sheep to any great extent during the spring and summer months when there is sufficient other forage more agreeable to the taste. However, in seasons when the supply of more palatable forage is short or scanty and in some months is almost completely exhausted, sheep will graze the chokecherry in amounts sufficient to cause either slow or rapid poisoning. Both types of poisoning usually result in death.

Description of the Chokecherry.

The chokecherry belongs to the plum family. But it differs from other members of this family in the fact that the leaves appear before the flowers, and that it does not come into full bloom until it is almost in full leaf.

The chokecherry ranges in height from a low-growing bush to a small tree. Sometimes it forms low thickets around damp places on dry hillsides, often it grows to greater height in the neighborhood of isolated mountain springs. Again, along mountain streams it may reach a height of 25 feet or more and take on a tree-like form where it finds congenial conditions of soil and moisture.

The leaves usually begin to appear in April and the bush is in full leaf late in May. The leaves are then oblong, dark green and glossy, rounded at the base and tapering at the tip. The full-grown leaf is about twice as long as it is broad; the margins are slightly toothed. Somewhere between the middle of May and the first few weeks in June the chokecherry bushes are covered with a mass of white flowers growing in long drooping clusters. At this season the shrub is very ornamental and it has in fact been brought under cultivation because of the beauty of the flowers and the foliage.

The flower clusters are replaced by pendant clusters of fruits, each containing a pit like a small cherry stone. Late in the summer the color of the fruit changes from dark green to a ruddy purple, which becomes almost black at the time of the first frost. When nearly ripe

Leaves, Fruit, and Flowers of the Western Chokecherry.

the red chokecherries are bitter and astringent; but later in the season. when they have turned deep purple and are almost ready to drop from the stem, the taste becomes more agreeable. They are then often gathered in considerable quantities and eaten or made into preserves.

The Relation of the Local Distribution of the Chokecherry to Poisoning.

On the range the chokecherry is most commonly found growing along the beds of streams or around springs or in quite isolated thickets or groves on the sides of canyons and hillsides.

Such a distribution, especially on a closely grazed or overgrazed range, tends to create a condition that favors poisoning by chokecherry leaves for the reason that the isolated clumps of chokecherry on mountain or hillside or along streams or around springs are cool, shady places such as sheep always seek during the warm part of the day.

When hungry sheep or sheep not completely satisfied "shade up" among chokecherry bushes, it is probable that some of them will browse upon the leaves for more or less prolonged periods and that they will eat a considerable quantity.

Even under such conditions as these most of the sheep will not graze the chokecherry to the point where poisoning follows. However, there will usually be a few sheep that eat enough of the leaves to cause them to show symptoms of poisoning. Some of them will be only slightly poisoned and will recover promptly. Others, more severely poisoned, will die in a few hours; though death may be deferred for a day or more. This depends upon the moisture content of the stomach as well as upon the quantity of leaves eaten.

The Time of the Year when the Chokecherry is Poisonous.

Chemical analyses to determine the quantity of hydrocyanic acid found in the leaves at different periods show that from the time when the leaves are produced in the spring until the latter part of August or early September the chokecherry leaves are highly poisonous.

After late summer the amount of poison falls off rapidly, and the danger decreases to a point where the chokecherry leaves may even be considered good fall browse.

This latter statement has been verified by experimental feedings in late summer in which sheep were fed large amounts of the chokecherry leaves without causing any recognizable symptoms of poisoning. It has been further verified by range observations where flocks of ewes after the lambs had been weaned or removed grazed liberally and continuously in early autumn on the chokecherry as one of their main sources of forage.

The Relation of Forage Supply to Poisoning.

The leaves of the chokecherry are really not relished by sheep until early fall, at which time the leaves not only lose a large part of their poisonous principle but also become more pleasing to the sheep's taste.

Therefore, on a range supporting a fair amount of forage which sheep prefer there is little danger from chokecherry poisoning provided the sheep are not being hurriedly trailed over such a range. If they are trailed rapidly and hazed along by dogs and herders, then they have no chance to select the plants that they prefer and may eat dangerous quantities of chokecherry or other poisonous plants.

In handling sheep on a range where the chokecherry grows the danger from poisoning is always greatest when the grass and other desirable and harmless plants give out early and are almost gone at the time when the chokecherry leaves are most poisonous.

Slow Chokecherry Poisoning.

Range observations show that the action of chokecherry poisoning may be either slow or rapid, depending upon the forage conditions and the distances between springs and streams available for the watering of the sheep.

Slow chokecherry poisoning occurs on ranges where the forage is more or less dry and coarse and where the sheep go for a period of several hours without an opportunity to drink.

The sheep graze upon the coarse dry forage; and if the chokecherry plant is present, they frequently browse upon its leaves. The chokecherry leaves remain in the first stomach with the mass of more or less dry forage. There is little absorption from the half-dry mass until after the animal takes a drink. Digestive activity then starts, the

Chokecherry Branches Stripped of Leaves by Grazing Animals.

poison is set free from the leaves, and symptoms of poisoning appear almost immediately. The severity of the poisoning depends upon the quantity of chokecherry leaves in the stomach.

Sheep which have grazed freely upon the leaves often show the poisoning symptoms so promptly after drinking that the herder thinks the drinking water must contain a violent poison. Animals so severely poisoned do not get very far away from the stream before showing signs of poisoning as a result of the liberation and absorption of the hydrocyanic acid. However, if the sheep have not grazed freely upon the chokecherry leaves, the symptoms develop more slowly. In fact the poisonous material may be liberated so gradually that the sheep will show symptoms for a day or more before either dying or recovering.

Rapid Chokecherry Poisoning.

Rapid chokecherry poisoning occurs when the sheep eat a considerable quantity of the fresh green leaves in a short space of time and the stomach contents are moist enough to set free promptly a large quantity of the poisonous principle. The poison is absorbed rapidly, poisoning develops quickly, and the animal dies within a brief period, usually within an hour.

This type of poisoning is in decided contrast to slow poisoning where a sheep may carry around in its first stomach for a day or more a mass of dry forage mixed with a fatal amount of chokecherry leaves without showing any visible poisoning symptoms until after taking a drink. Further, even after taking a drink, although the poisoning symptoms develop promptly, the liberation of the hydrocyanic acid may be so

Chokecherry Bushes in Late Summer.

slow that instead of dying immediately the sheep may show symptoms for a day or more before death or recovery.

Such animals may breathe with difficulty for many hours, the difficulty being increased by the least muscular exertion. If they are driven or hurried by dogs they fall and often die.

Amounts Necessary to Make Sick or Kill.

The quantity of chokecherry leaves required to cause visible poisoning symptoms varies with the season, the moisture and forage content of the stomach, the size of the animal and the rapidity with which the leaves are taken into the stomach.

During the early spring and continuing until late summer, the leaves contain their highest percentage of hydrocyanic acid.

An average of all the feeding tests with sheep made between April 24 and August 28 at the Field Laboratory of the Nevada Station showed that for each 100 pounds of animal live weight it took 3.23 ounces of the leaves to cause slight poisoning symptoms; 3.50 ounces to cause

severe sickness followed by recovery; and 4.30 ounces or a little more than one quarter of a pound to cause death.

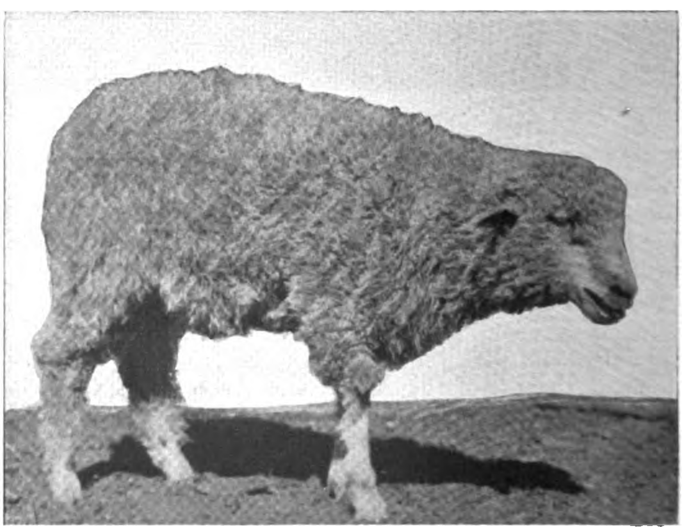
In the feeding tests made later than August 28, it was evident that the leaves had lost most of their poisonous properties; for in all the feedings made at this season only two sheep showed symptoms of poisoning and the effect in each case was slight. The other feedings made in the autumn caused no symptoms even though the animal ate leaves at the rate of nearly a pound, 15.19 ounces, per hundred pounds of live weight.

The size of the animal influences its susceptibility to becoming poisoned with a given quantity of leaves. The larger the animal the greater the quantity of leaves necessary to produce poisoning. Strong robust sheep have a better chance to recover from chokecherry poisoning than have animals weakened by various causes such as old age, insufficient feed, etc.

The moisture and forage content of the stomach controls in a large measure not only the rapidity with which poisoning symptoms develop but also the severity of the poisoning. Sheep that eat rapidly a considerable quantity of chokecherry leaves when there is much moisture in the stomach will develop poisoning symptoms quickly and usually die. On the other hand what would be a fatal quantity of chokecherry leaves under the above conditions may not prove fatal if the stomach contents are so dry that there is only a slow liberation and absorption of the poisonous principle from the leaves.

Relation Between Elimination of Poison and Sheep Losses.

Feeding tests have shown that when the conditions for the rapid production of hydrocyanic acid are right then the poison is absorbed quickly. If absorption is so great that the limits of possible elimination are passed, then death follows. On the other hand, if the poison is generated in small quantities it is rapidly eliminated from the system.



The first stage of poisoning which may lead to either death or recovery. This is a period of uneasiness in which the animal is constantly changing position, and the breathing becomes difficult.

Second stage of poisoning in which the animal has lost muscular control. In this period there are violent convulsions, labored hurried breathing, open mouth with hanging tongue, and pronounced gasping and strangling.

Final stage of poisoning in which convulsions come and go, gradually ceasing, and the animal lapses into insensibility. This is the beginning of the end. The animal lies motionless on the ground with outstretched legs, except for intervals when there are a few seconds of a feeble running movement of the legs. Breathing and heart action have almost ceased. Bloating begins and gradually increases until death. Respiration ceases entirely. The pulse continues for a few moments, stops, and death follows.

This accounts for the fact that on many ranges there is evidence of the chokecherry leaves having been grazed with no sheep losses.

The leaves had been eaten in small quantities at irregular intervals, permitting the hydrocyanic acid to be liberated, absorbed and eliminated without causing poisoning. Therefore, within the period of a day or even a few hours sheep may eat without injury an amount equal to many times the fatal dose if the quantity eaten at any one time is small and moisture conditions favor the prompt production and elimination of the poison. However, if the conditions are not right for the immediate setting free of the hydrocyanic acid from the leaves as soon as they are taken into the stomach, then the eating of small quantities from time to time may finally cause such an accumulation as to cause severe poisoning or even death. This will follow just as soon as the animal drinks and sets up a condition which causes the liberation of the hydrocyanic acid from the accumulation of leaves that have been reposing in quite a harmless manner in the first stomach.

Do Sheep Become Immune to Chokecherry Poisoning by Eating Small Quantities of Leaves Daily?

Daily experimental feedings of small quantities of the chokecherry leaves failed to build up any tolerance toward the poison. Sheep which had been so fed showed only the normal capacity for recovery after eating dangerous quantities of the leaves. Evidently, therefore, range sheep are not rendered immune or partially immune to the hydrocyanic acid by daily grazing of small quantities of the chokecherry leaves.

Symptoms of Poisoning.

The general course of fatal poisoning may be separated into four stages: (1) A period of uneasiness during which the poisoned animal will walk or run a short distance and then stop. This period of constant movement and rapid change of position is followed by the second stage. (2) In this stage respiration is difficult, muscular control is lost, the gait becomes unsteady and the animal totters and falls. (3) During the third stage extreme difficulty in breathing is shown by the wide open mouth with hanging tongue, a mucous discharge from the nostrils and very pronounced gasping and strangling. The animal struggles and its convulsions are severe and almost continuous. The eyes roll, the pupils are dilated. There is usually a muscular twitching of the lips, eyes, or flanks. The convulsions subside slowly and the animal lapses into almost complete insensibility. This is the beginning of the fourth stage, which is brief. (4) The poisoned animal lies motionless on the ground with outstretched legs. At intervals there may be for a few seconds a feeble running movement of the legs. Breathing and heart action have almost ceased. Bloating begins slowly and gradually increases. The respiration ceases entirely and the pulse continues for a few minutes, stops, and death follows.

Possible Remedies.

The action of the poisonous principle of chokecherry leaves is very rapid; and the poison, hydrocyanic acid is so deadly that on the range there is no opportunity for the use of any remedies. During the summer season of 1927 several remedial measures were tried on sheep poisoned with chokecherry leaves. All the measures used failed to keep the sheep alive. These measures included the use of iron sulphate and sodium carbonate, chlorine, ground charcoal, and glucose in the form of corn syrup.

Handling Sheep on a Range Supporting the Chokecherry Plant.

While the leaves of the chokecherry contain one of the most powerful poisons known, nevertheless sheep may be grazed safely on ranges where the chokecherry grows if the following conditions are faithfully observed: (1) Sheep must be driven slowly over such ranges; for this will give them a chance to spread out and to select their food. (2) The range must not be overgrazed or closely grazed, otherwise the sheep will graze frequently and excessively upon the chokecherry. Ordinarily the leaves are not eaten in dangerous quantities unless there is a distinct shortage of palatable and nutritious forage plants. (3) Sheep must not "shade up" or "bed down" for prolonged periods in the same chokecherry areas along streams or in chokecherry thickets or groves on the sides of canyons for such a practice overgrazes or closely grazes these areas and creates conditions favorable to chokecherry poisoning.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 111 RENO, NEVADA March, 1928

PRELIMINARY REPORT ON

A Study of Cattle Production Costs In Nevada

This is a statement of the character and purposes of a study of the cost of producing cattle on ranch and range in Nevada now in progress in the Experiment Station, with an analysis of the factors that influence costs and profits, and an illustrative application of these factors to a theoretical herd

By

C. A. BRENNEN
Range Economist

and

GRANT H. SMITH, JR.
Of the Department of Range Management

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[55]

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

HON. GEORGE WINGFIELD (1929)	Reno
HON. G. F. TALBOT (1931)	Reno
HON. FRANK E. WILLIAMS (1933)	Goodsprings
HON. WALTER E. PRATT (1935)	Reno
HON. GEORGE F. BROWN (1937)	Reno

OFFICERS

WALTER E. CLARK, Ph.D.	President of the University
CHARLES H. GORMAN	Comptroller
GEORGE H. TAYLOR	Secretary Emeritus
CAROLYN BECKWITH	Secretary

STAFF

SAMUEL B. DOTEN, M.A., Director	Entomologist
CHARLES E. FLEMING, B.S.A.	Range Management
EDWARD RECORDS, V.M.D.	Veterinary Science
GEORGE HARDMAN, M.S.	Assistant in Irrigation
M. R. MILLER, M.S.	Chemist
LYMAN R. VAWTER, D.V.M.	Assistant in Veterinary Science
F. L. BIXBY, C.E. (Bureau of Public Roads, Irrigation Division, U. S. D. A.)	Irrigation
ROBERT STEWART, Ph.D.	Soil Fertility
CHESTER BRENNEN, B.A.	Economist in Range Management
GRANT H. SMITH, JR., B.S.	Assistant Range Economist
F. B. HEADLEY	Farm Development
R. M. CLAWSON, B.S.	Assistant in Farm Development
McKEAN CARTER, A.B.	Fellow in Chemistry
ANDREW YOUNG	Assistant in Range Management
MATILDA MARSHALL	Specialist in Farm Cost Studies
LOUISE LEWERS	Secretary to Veterinary Science
MARTHA R. BRUCE	Illustrator and Secretary
GRACE COSTELLO	Librarian and Secretary to Director

SECTION I

A Statement of the Character and Purposes of the Cost of Production Study Which Is Being Carried on by the Agricultural Experiment Station of the University of Nevada.

REASONS FOR UNDERTAKING THE PROJECT

Studies of the cost of production of beef cattle in Nevada were undertaken at the urgent request of the Nevada Land and Livestock Association, the Nevada State Farm Bureau, the Western Cattle Marketing Association, and the Nevada Banker-Farmer Conference of 1927. For several years these organizations have felt a growing need of adequate and accurate figures on the production of live stock under Nevada conditions.

PURPOSES

The central purpose of this project is to obtain information on the following topics:

(1) The basic general operating costs of the cattle business on ranch and range in Nevada.

(2) The exact amounts and ratios of such costs in the cattle business in Nevada.

(3) Segregated cost information that will show how ranch operations in Nevada may be made more efficient.

(4) Information that will form a foundation for intelligent and fair judgments upon the economics of land tenure and grazing rights and privileges in Nevada.

(5) Basic facts of the relationship between livestock investments and capital investments that will be of general benefit to banking and to the livestock business.

Detailed information of this type will be obtained under a variety of cattle ranch and range conditions.

THE CHOSEN METHOD OF STUDY

There are various methods by which a study of this kind might be made. A general survey of the cattle business covering a large number of ranches in a short time would yield information, from which an analysis of the business might be made. Still, the final analysis would not be founded so much on actual records as on the cattleman's memory and the scant and fragmentary records usually kept. Such a general survey would inevitably include misinformation, inaccurate statements, and a good deal of guess work.

The method chosen by the Station, however, is far more difficult and expensive. The Station enters into cooperative relationships with the cattleman in keeping actual records through a term of years of all the factors entering into the cost of producing beef cattle for the market.

These records are confidential in character and are kept primarily for the rancher's own private use. Only the general conclusions drawn from the records will be published by the Station, and then in such a form that the facts stated cannot be identified or connected with any individual ranch.

DETAILS OF THE METHOD OF STUDY

Evidently the first step toward a working knowledge of any business is a clear understanding of the general conditions that govern production. Cattle are produced in Nevada under a number of different conditions and systems which may be grouped as follows:

(1) Cattle are handled jointly on ranch and range holdings.
(2) Cattle are handled yearlong on privately owned ranch lands.
(3) Cattle are handled on ranch property and leased range lands.
(4) Cattle are handled on a yearlong range basis, with land investment necessary to give control of range feed and stock water.

For the purposes of the present study, the ranches selected handle their cattle jointly on ranch and range holdings. They keep a fairly constant breeding herd for the production of two-year-old steers and mixed cows to be sold annually as beef and feeders. These ranches are on a straight cattle production basis. Speculative operations are eliminated. Outfits running both sheep and cattle are not included.

RANCH BOOKKEEPING

A brief preliminary survey showed that an adequate and suitable method of bookkeeping for cattle ranches had to be worked out and put into use on the cooperating ranches in order to meet the requirements of this project. Of primary importance was the task of getting bookkeeper cooperators with sufficient training, and representing suitable cattle outfits to take hold of the project. Details of the system of accounts to be used in obtaining and recording the desired information will have to be worked out as the project progresses. A set of books was compiled at the outset to fit the known ranch conditions, with the intention of adding to the method or altering it from year to year as conditions might demand. The system finally devised by the authors with the assistance of cooperating ranchers and others interested appears to be simple, elastic, and adapted to practical use, with detail sufficient to show separate operation costs.

The set consists of a Cattle Ranch Record Book and a Time and Memorandum Book. The records are designed to enable the bookkeeper to segregate and to enter separately the various items pertinent to the cost of each important ranch operation. Items of record, such as bills paid and cancelled checks are held on file and posted directly into the Record Book. Miscellaneous items such as wages, cash expenditures and receipts, are entered currently in the Time and Memorandum Book, and are posted later to the Ranch Record Book under the separate ranch operations. The study is being carried on by the route method, and visits to the ranches along each route are made frequently by a field man who supervises the work and assists in keeping the records.

Costs of the various ranch operations are computed and summarized and the necessary data are carried forward and entered in a section of the Ranch Record Book entitled Segregated Ranch Costs.

Forms for cost analysis are set up in the Record Book, showing the following cost factors:

(1) Cost of Hay Production.
(2) Cost of Feeding Hay to Live Stock.
(3) Cost of Irrigating Hay Lands.

(4) Cost of Keeping the Necessary Ranch Horses.
(5) Cost of Labor and of Family Board.
(6) Cost per Head of Operating a Mixed Herd.
(7) Cost Ratios of Important Items Entering into the Production of Cattle.

To each of the cooperating stockmen the greatest direct value of these cost studies will spring from a new and detailed knowledge of his own business and the cost of every operation in his year's work.

In the final analysis, averages will be taken of the various cost factors for cattle-producing sections of similar character in order to establish representative cattle ranch production costs. Figures obtained in this manner, showing the comparative costs among the several systems of handling cattle, are expected to be highly valuable to the industry, to the general public, to the people who finance the business, and to agencies of both State and Federal governments. They should establish a fair and intelligent understanding of the economics of cattle production and land tenure in Nevada.

SECTION II

An Explanation of the Four Main Factors of Production and Their Relation to Profit or Loss:

1. **The Running Cost Per Head Per Year.**
2. **The Percentage of Calf Crop.**
3. **The Percentage of Death Loss.**
4. **The Selling Price Per Head.**

INTRODUCTION

At the beginning of this study certain well known factors that affect profit or loss in the cattle business are distinguished. Their bearing on the financial statement will vary with different ranches, according to the management. Requests were received from several interested ranchers and business men expressing a desire to have these various factors entering into management tabulated for immediate use. This bulletin is preliminary in character and has been written to meet the requests that have already been received for this type of information. It therefore presents the following material in a form which it is believed may be of value to stockmen, bankers and others interested in the livestock business.

In any business the factors which enter into the analysis of profit or loss are hard to determine because of the variations in methods and conditions. It is even more difficult in agricultural pursuits, as the factors which govern them are especially complicated because the manager is dealing with natural elements over which he has little or no control. Drought, storm, wind, rain, and cold greatly increase the risks in the cattle business; for live stock are entirely dependent on the elements for the conditions of their existence. However, when all these variables have been accounted for, profit and loss depend upon the following four main factors:

(1) The running cost per head per year.
(2) The percentage of calf crop.
(3) The percentage of death loss.
(4) The selling price per head.

RUNNING COST

The running cost per head per annum is the sum total of all cost items covering ranch operations for the year, divided by the number of cattle on hand at the beginning of the year.

Within the last seven years this item in the cattle business has been cut to the core. Only those operators who were able to reduce their overhead to the minimum have been able to stay in the business. Cattlemen made their old machinery do another year, cut down their labor, and added more hours to their own time. Still, it is fully to be expected that the cost studies now in progress will point to ways of reducing running costs still further by finding existing leaks where various ranch operation costs are excessive.

CALF CROP

This is a vital factor in the cattle business. A recent study of the calf crop in Nevada by Dr. W. H. Hilts showed that the number of calves born varied between 25 and 95 per cent of the breeding cows, with an average for the State of about 60 per cent. At weaning time the average was found to be nearer 55 per cent. Too often cattlemen go on producing without paying any great amount of attention to this important item and within a few years financial embarrassment and failure are certain to follow. Good cattlemen point to many instances where neighbors have gone broke without realizing that an exceedingly small calf crop was the real cause.

It is recognized that group action is necessary in order to get the highest percentage of calf crop. However, there are many things that a rancher can do to increase his calf tally. Often, on the same range and under what appear to be the same conditions, one rancher will get a seventy-five per cent calf crop while his neighbor gets only fifty per cent. This is apt to mean the difference between success and failure. The table that accompanies this article shows this fact more clearly. The reason for emphasizing this vital cost factor is to show that there must be the proper relationship between the annual calf crop obtained and the running cost per head per year in order to insure economic production.

Important factors that cause low calf crop production are:

(1) Inadequate supply of bulls.

(2) Bulls not acclimated, in poor condition, unevenly distributed, and often too old.

(3) No provision made to supply fresh bulls for service when cattle are gathered.

(4) Cows not in thrifty breeding condition due to poor range, insufficient balanced winter rations, or a combination of both.

(5) Heifers bred too soon, causing them in many cases to skip a year before calving again.

(6) Big calves allowed to suck the cows, often causing the cow to lose her next calf, or run down in flesh and pass a year.

(7) Abortions and genital diseases.

(8) Losses due to lack of care and shelter, especially true among new-born calves in the winter months.

(9) Keeping breeding stock, calves, and mixed classes of cattle in the same pastures.

It can easily be conceived that by increasing the calf crop percentage and reducing the breeding herd proportionately the same annual beef turnoff could still be produced. It would naturally follow that the ranges would have a lesser number of breeding cattle to carry, making for better grazing. This condition would also make the supply of ranch forage crops more adequate.

DEATH LOSS

The calf crop is only the first step; the next one is to raise the calves to a profitable maturity by keeping the death losses as low as possible. This requires skill, experience, and effort. A lifeless carcass on the field represents that much value taken directly out of the business. Death losses constantly occur. Often they are unavoidable, but many

of them are easily prevented. This is true of blackleg, a disease that is now almost wholly under control.

Losses due to poisonous range plants are a harder matter to handle; but the center of the poisonous plant problem on the range is in itself another problem, that of using the range and still keeping it in thriving condition. The work done by C. E. Fleming, Chief in Range Management in the Nevada Station, has shown very clearly that cattle and sheep do not relish the poisonous plants; that most of these plants are in fact repellent, and are eaten only when the ranges are short of grass and other feed and the grazing animals eat plants that they ordinarily will not touch.

Cattlemen estimate that on an average death losses from disease, accident, and poisoning take five animals out of every hundred produced on ranch and range in Nevada, a figure that makes a severe cut in possible profits.

MARKET PRICE

The turning point toward profit or loss in the cattle business is in the price per head obtained on the market for beef and feeders. The overhead may be as low as possible, the calf crop good, and the death loss low; but unless the right price is finally obtained, the business may still fail to pay.

The first three cost factors, namely Running Cost, Calf Crop Percentage, and Death Loss, are more or less under the grower's control. The fourth, Market Price Received, in a large measure determines whether the business shows a profit or a loss. This factor in the cattle business has been sadly neglected and it is only recently that growers have combined their efforts to stabilize prices through orderly marketing. For example, the Western Cattle Marketing Association in California has recently made great strides in cooperation and has accomplished more than all other agencies on the Pacific Coast in bettering market conditions.

It is obvious that if cattlemen in general use improved practices to correct existing losses in the business and keep the bulk of their heifer calves, then the inevitable result will be over-production, followed later by liquidation and falling prices.

Stockmen should strive for economic production, at the same time heeding the advice of well-informed men in the business who sound this note of warning against unwarranted expansion:

> There are indications that cattlemen throughout the western producing States are quite generally making plans for largely restoring the depleted ranges and pastures. There is an element of serious danger in this. The cattle business has been noted for its ups and downs throughout its entire history. The temptation to overstock recurs with every upward curve of prices. Yielding to this temptation has bankrupted more cattlemen than all other causes combined. Frozen cattle paper has caused more bank failures throughout the West than anything else.
>
> Moderate expansion of the cattle business is justified, but stockmen who again plunge headlong into debt will be fortunate, indeed, if they get out again before another price collapse.
>
> —*The Agricultural Review, December, 1927.*

SECTION III

THEORETICAL HERD

The following tables and charts show the relation of running cost and calf crop percentage to profit and loss, figured on the basis for constant breeding herd of one hundred head. On this basis Nevada cattlemen can make interesting applications of the facts of the tables to their own conditions, for they bring out the relative importance of the various factors entering into production.

The results obtained depend upon the completeness and accuracy of the ranch accounts used in the compilation. Where ranch records are not kept estimates must be used as a guide:

TABLE I

Profit and Loss—Theoretical Herd

Running cost per head per year	*Calving per cent at weaning*	*Death loss per cent*	*Beef turnoff, per cent cows and steers*	*Average production cost per head*	*Average 1927 market price per head*	*Profit or loss per head*	
						A. On beef turnoff	*B. On breeding herd*
$10.00	85	5	27	$37.03	$70.00	$32.97	$8.90
10.00	80	5	26	38.46	70.00	31.54	8.20
10.00	75	5	25	40.00	70.00	30.00	7.50
10.00	70	5	24	41.66	70.00	28.34	6.80
10.00	65	5	23	43.47	70.00	26.53	6.10
10.00	60	5	22	45.45	70.00	24.55	5.40
10.00	55	5	21	47.61	70.00	22.39	4.70
10.00	50	5	20	50.00	70.00	20.00	4.00
12.00	85	5	27	44.44	70.00	25.56	6.90
12.00	80	5	26	46.15	70.00	23.85	6.20
12.00	75	5	25	48.00	70.00	22.00	5.50
12.00	70	5	24	50.00	70.00	20.00	4.80
12.00	65	5	23	52.17	70.00	17.83	4.10
12.00	60	5	22	54.54	70.00	15.46	3.40
12.00	55	5	21	57.14	70.00	12.86	2.70
12.00	50	5	20	60.00	70.00	10.00	2.00
14.00	85	5	27	51.85	70.00	18.15	4.90
14.00	80	5	26	53.84	70.00	16.16	4.20
14.00	75	5	25	56.00	70.00	14.00	3.50
14.00	70	5	24	58.33	70.00	11.67	2.80
14.00	65	5	23	60.86	70.00	9.14	2.10
14.00	60	5	22	63.63	70.00	6.37	1.40
14.00	55	5	21	66.66	70.00	3.34	0.70
14.00	50	5	20	70.00	70.00	0.00	0.00
15.00	85	5	27	55.55	70.00	14.45	3.90
15.00	80	5	26	57.69	70.00	12.31	3.20
15.00	75	5	25	60.00	70.00	10.00	2.50
15.00	70	5	24	62.50	70.00	7.50	1.80
15.00	65	5	23	65.21	70.00	4.79	1.10
15.00	60	5	22	68.18	70.00	1.82	0.40
15.00	55	5	21	71.42	70.00	–1.42	–0.30
15.00	50	5	20	75.00	70.00	–5.00	–1.00
16.00	85	5	27	59.25	70.00	10.75	2.90
16.00	80	5	26	61.53	70.00	8.47	2.20
16.00	75	5	25	64.00	70.00	6.00	1.50
16.00	70	5	24	66.66	70.00	3.34	0.80
16.00	65	5	23	69.56	70.00	0.44	0.10
16.00	60	5	22	72.72	70.00	–2.72	–0.60
16.00	55	5	21	76.19	70.00	–6.19	–1.30
16.00	50	5	20	80.00	70.00	–10.00	–2.00
18.00	85	5	27	66.66	70.00	3.34	0.90
18.00	80	5	26	69.23	70.00	0.77	0.20
18.00	75	5	25	72.00	70.00	–2.00	–0.50
18.00	70	5	24	75.00	70.00	–5.00	–1.20
18.00	65	5	23	78.26	70.00	–8.26	–1.90
18.00	60	5	22	81.81	70.00	–11.81	–2.60
18.00	55	5	21	85.71	70.00	–15.71	–3.30
18.00	50	5	20	90.00	70.00	–20.00	–4.00

TABLE I—*Continued*

Running cost per head per year	*Calving per cent at weaning*	*Death loss per cent*	*Beef turnoff, per cent cows and steers*	*Average production cost per head*	*Average 1927 market price per head*	*Profit or loss per head* A. *On beef turnoff*	*Profit or loss per head* B. *On breeding herd*
$20.00	85	5	27	$74.07	$70.00	–$4.07	–$1.10
20.00	80	5	26	76.92	70.00	–6.92	–1.80
20.00	75	5	25	80.00	70.00	–10.00	–2.50
20.00	70	5	24	83.33	70.00	–13.33	–3.20
20.00	65	5	23	86.95	70.00	–16.95	–3.90
20.00	60	5	22	90.90	70.00	–20.90	–4.60
20.00	55	5	21	95.23	70.00	–25.23	–5.30
20.00	50	5	20	100.00	70.00	–30.00	–6.00

This table shows the effect of running cost and percentage of calf crop on profit or loss.

Column 1. The running cost per head per year is the sum total of all cost items covering ranch operations for the year divided by the number of cattle on hand at the beginning of the year.

Column 2. The calving percentage at weaning time varies from 50 to 85 per cent.

Column 3. The death loss is taken as being constant.

Column 4. The beef turnoff is the number of cattle available for market per hundred head and varies in proportion to the calf crop.

Column 5. The average production cost per head is obtained by dividing the beef turnoff into the running cost.

Column 6. The average 1927 market price per head for northeastern Nevada *grass* cattle (beef and feeders) is obtained as follows:

STEERS—2–2½ years:

1060 pounds................
1000 pounds................
940 pounds................

$$\frac{3000 \text{ pounds}}{3} = 1000 \text{ lb} \ @ \ 8\tfrac{1}{8}\text{c} = \$81.25$$

COWS—All ages:

⅓ young fat cows........1000 lb @ 6¼c = $62.50
⅓ mixed cows...............1000 lb @ 6c = 60.00
⅓ rough off cows.........1000 lb @ 4¼c = 42.50

$$\frac{\$165}{3} = \$55.00$$

Assuming that the calves born are equally divided, steers and heifers. the herd under average Nevada conditions should have available for market annually about 4 steers to every 3 cows.[1] Therefore, the average market price for northeastern Nevada grass cattle (beef and feeders) is:

4 steers @ $81.25..$325.00
3 cows @ $55.00.. 165.00

$$\frac{\$490}{7} = \$70.00$$

For sections of the State where the weight and price received varies materially from the above figure another market price should be computed on the above basis and substituted.

Column 7. Profit or loss per head.

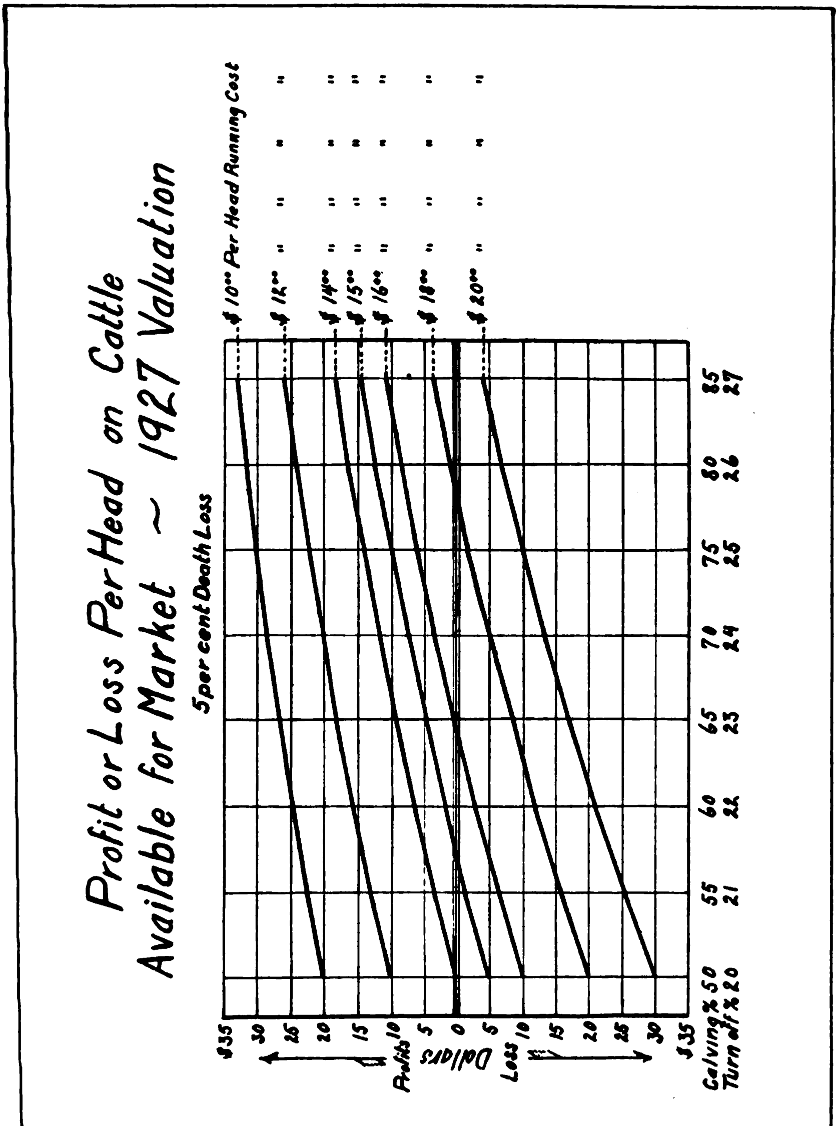
A. On the Beef Turnoff—Here is found the profit or loss per head on animals available for market, which varies in accordance with the running cost and calf crop.

[1]It is realized that in this theoretical herd where a constant breeding herd is maintained, the ratio of 4 steers to 3 cows (sold annually as beef or feeders) will vary in proportion to the percentage of calf crop. However, this ratio will apply to the immediate practical purpose.

B. On the Breeding Herd—Here the profit or loss is allocated to the entire breeding herd.

In using this table the stockman should locate his running cost per head per year and his calving percentage in columns one and two; the figures that follow across will give theoretically his annual beef turn-off percentage, his average production cost and, in the last columns, his profit or loss per head, the first of which is the profit or loss per head on the cattle available for market, and the second the profit or loss allocated to the entire breeding herd.

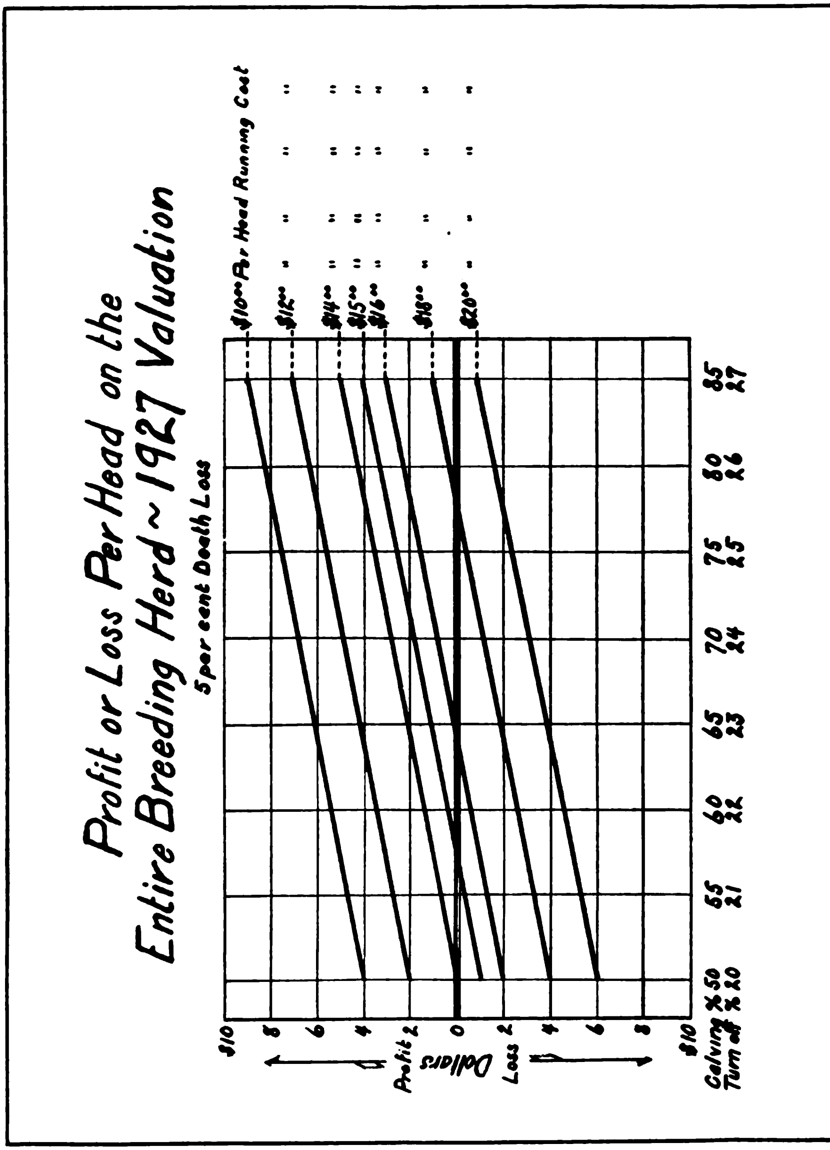
CHART NUMBER 1



It is interesting to note in this table that, with a 55 per cent calf crop at weaning time and a 5 per cent death loss, the stockman must keep his running cost well under $15 per head per year in order to stay in the business.

It is indeed a fortunate cattleman who can hold his annual running cost as low as $10 per head and get a calf crop percentage of 55. With these figures, his profit per head on beef cattle available for market annually will be $22.39 which, when allocated to the entire herd, reduces to $4.70 profit per head. In contrast, the rancher who has a

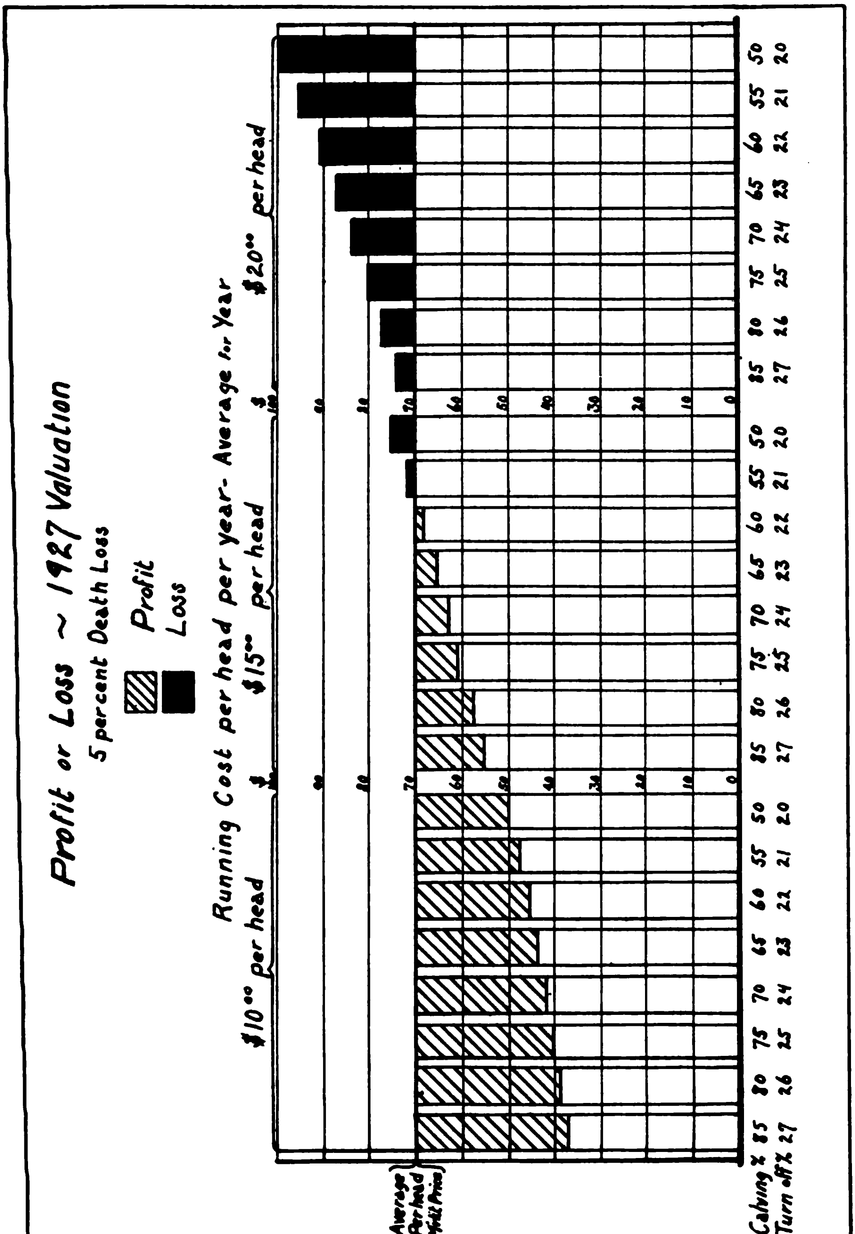
CHART NUMBER 2



$15 per head running cost and a 55 per cent calf crop loses $1.45 per head on beef available for sale annually, or $0.29 per head on the entire herd.

In this table it can also be seen that for every $2 raise in the running cost there must be an increase of approximately 15 per cent in the calf

CHART NUMBER 3



crop; *i. e.*, with a $12 running cost and a 55 per cent calf crop the per head profit on the entire herd is $2.70; with a $14 running cost and a 70 per cent calf crop the per head profit is $2.80. This same condition follows through the entire table.

Chart Number 1 shows the profit or loss per head on the beef turnoff (at 1927 grass cattle market prices) from a constant breeding herd. It is a graphic representation of figures given in Table I, Column 7-A. It can be clearly seen that at a given running cost the profits increase and the losses decrease as a result of a larger calf crop percentage, *i. e.*, if a cattle outfit can hold its running cost per head as low as $10 and at the same time get a calf crop of 50 per cent or better it is assured a good profit. Those who have a $14 per head running cost and a 50 per cent calf crop just break even. But if they can increase their calf crop percentage to 65 and maintain the same running cost they will show a profit of $9 per head. Those who have a $20 per head running cost are producing at a loss even though they get a 95 per cent calf crop.

Chart Number 2 is a graphic representation of the figures given in Table I, Column 7-B. It will be noted that there is the same trend as in Chart Number 1. This is true, as the only difference between them is that in the first chart the profit and loss is shown on cattle available for market and in the second it has been allocated to the entire herd.

From these charts it is clear that a $12 running cost with a 50 per cent calf crop and a $14 running cost with a 65 per cent calf crop will produce equal profits, in round numbers, provided the cattle are of equal quality and grade. Evidently each stockman must determine the best relationship between running cost and calf crop percentage for economic production under his own ranch and range conditions. The average Nevada stockman should strive to increase his calf crop without materially increasing his running cost per head, and at the same time turn off a good product.

Chart Number 3 shows the per head production cost and profit or loss on the beef turnoff from constant breeding herds having calf crops of from 50 to 85 per cent, with a running cost of $10, $15 or $20 per head.

ACKNOWLEDGMENT

As a source of detailed information upon the calf crop in Nevada the authors made use of Nevada Agricultural Extension Bulletin No. 57, "A Study of the 1924 Calf Crop in Nevada," by Dr. Walter H. Hilts, Veterinary Inspector of the State Board of Stock Commissioners.

The method of determining the beef turnoff was taken from Oregon Agricultural Experiment Station Bulletin No. 220, "The Cost of Producing Beef on the Ranges of Eastern Oregon," by E. L. Potter.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 112 | RENO, NEVADA | April, 1928

The Development of Water Supplies for Irrigation In Nevada By Pumping From Underground Sources

BY

F. L. BIXBY and GEORGE HARDMAN

Written by the junior author as a report, in popular form, of information gained by experimental pumping studies conducted in the Las Vegas Valley of southeastern Nevada

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[63]

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

HON. GEORGE WINGFIELD (1929)..........Reno
HON. G. F. TALBOT (1931)..........Reno
HON. FRANK E. WILLIAMS (1933)..........Goodsprings
HON. WALTER E. PRATT (1935)..........Reno
HON. GEORGE S. BROWN (1937)..........Reno

OFFICERS

WALTER E. CLARK, Ph.D..........President of the University
CHARLES H. GORMAN..........Comptroller
GEORGE H. TAYLOR..........Secretary Emeritus
CAROLYN BECKWITH..........Secretary

STAFF

SAMUEL B. DOTEN, M.A., Director..........Entomologist
CHARLES E. FLEMING, B.S.A..........Range Management
EDWARD RECORDS, V.M.D..........Veterinary Science
GEORGE HARDMAN, M.S..........Assistant in Irrigation
M. R. MILLER, M.S..........Chemist
LYMAN R. VAWTER, D.V.M..........Assistant in Veterinary Science
F. L. BIXBY, C.E..........Irrigation
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)
ROBERT STEWART, Ph.D..........Soil Fertility
V. E. SPENCER, M.S..........Associate, Soils Research
CHESTER BRENNEN, B.A..........Economist in Range Management
F. B. HEADLEY..........Farm Development
R. M. CLAWSON, B.S..........Assistant in Farm Development
MCKEAN, CARTER, A.B..........Fellow in Chemistry
ANDREW YOUNG..........Assistant in Range Management
MATILDA MARSHALL..........Specialist in Farm Cost Studies
LOUISE LEWERS..........Secretary to Veterinary Science
MARTHA R. BRUCE..........Illustrator, and Secretary to Director
GRACE COSTELLO..........Librarian and Secretary

FOREWORD

This bulletin is intended to present some general information concerning the pumping of water from wells for irrigation in southern Nevada. The material is not technical in character, for the writer feels that a statement of the general principles governing the development of underground water supplies is of greater present value to prospective settlers than either engineering data or information regarding conditions in limited districts. Many such districts have in fact been covered by published reports from various sources in a much more detailed manner than is possible in this bulletin.

It does not seem necessary to enter into detailed descriptions of the various types of pumps and methods of installing and operating them, when such information can be obtained directly from the manufacturers.

All available sources of information have been drawn upon freely. Acknowledgement of tabulated data and of formulas which were borrowed from other publications is made at various points in the text.

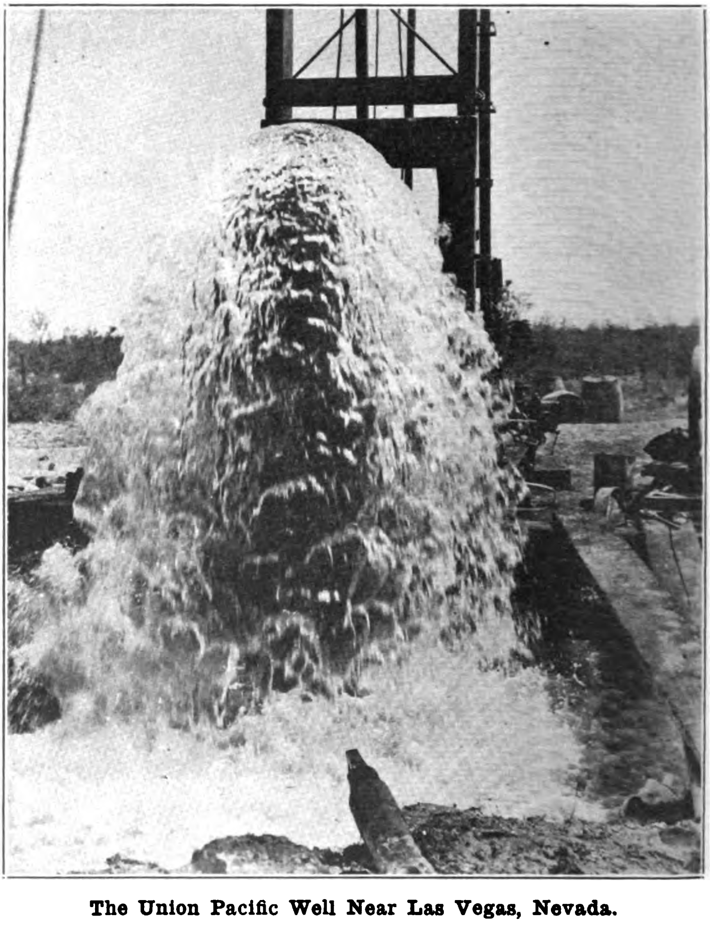
The writer is indebted to W. W. McLaughlin, Associate Chief of the Division of Agricultural Engineering, the Bureau of Public Roads, and the U. S. Department of Agriculture for many helpful suggestions in the preparation of the manuscript and for valuable advice and suggestions while the experimental studies of the water supply of the Las Vegas region were in progress.

GEORGE HARDMAN.

LAS VEGAS, NEVADA, February 1, 1928.

SUMMARY

1. Opportunities are present in Nevada in many localities for the development of new farming lands by pumping water for irrigation.
2. Conditions favorable to the underground storage of water may be found in many Nevada valleys.
3. The recovery of considerable amounts of water from the underground supplies is possible and feasible.
4. With few exceptions farming must follow the general type made necessary by the natural conditions. In Nevada this is livestock raising.
5. Wells should be located with due regard to possible underground supplies.
6. Wells should be sunk by an experienced driller, if possible.
7. Wells should be tested, to determine their capacity, before pumping equipment is purchased; and the type and size of the pump should be selected to meet the needs and conditions.
8. The water should be analyzed to determine its fitness for use in irrigation and for domestic purposes.
9. In Nevada the average cost of fuel for pumping is high, and the average value per acre of the crops grown is low. Under these conditions the limit of the maximum economical pumping lift is also low.



The Union Pacific Well Near Las Vegas, Nevada.

THE DEVELOPMENT OF GROUND WATER IN NEVADA BY PUMPING

INTRODUCTION

Nevada, with its 110,690 square miles of thinly populated territory, would appear to offer many opportunities to the homeseeker. For the man who understands local conditions, and who has the necessary financial means for developing a desert soil and bringing it under cultivation and into a producing state, such opportunities do indeed exist in ample measure. However, for the man who lacks the necessary financial resources the prospects are not enticing.

Natural conditions usually determine the general type of agriculture found in any community; and in Nevada such conditions have made the raising of live stock the dominant type of farming. Except in local instances livestock raising is, at present, the basic agricultural industry; and other types of farming are usually dependent upon the stock interests. A glance at a relief map of Nevada shows a series of nearly parallel mountain ranges with intervening narrow trough-like valleys. These valleys and mountains afford winter and summer grazing range for stock; but the rainfall over almost the entire State is too scanty to permit dry farming, and field crops are grown only under irrigation.

In some regions the local conditions of soil and climate favor the development of a different type of agriculture; but, except in a very few instances, distance from market and lack of transportation are handicaps too great to overcome. This is especially true in the more isolated undeveloped valleys where the opportunity to secure land and water is the best. It forces the development of such valleys to follow the general trend of the State's agriculture.

GEOLOGY AND WATER SUPPLY

During earlier geologic times many of the valleys in Nevada contained lakes, remnants of which are found in Walker and Pyramid Lakes, the "sinks" of the Carson and the Humboldt, the Ruby Lakes and many smaller intermittent lakes. Many of these former lakes were slowly destroyed by filling with lake sediments, while others ultimately found outlets to rivers or to lower valleys. The depth of the sedimentary deposits in these old lake beds may be very great. In the Las Vegas Valley bed rock is found only after drilling to a depth of about 1,100 feet, while in Railroad Valley, a few miles to the north, a well 2,000 feet deep ended in valley fill. The break of the Mormon mesa in the Virgin and Moapa Valleys exposes about 500 feet of fill material. These deep sediments allow the flow of large quantities of water below the surface, and in some cases permit the escape of water from one basin to another through the sediments or through cracks and crevices in the underlying rocks. Naturally the quantity of water required to saturate these underground sediments is very great and the yield from them when they are tapped by wells is correspondingly large.

RAINFALL

The average annual precipitation for Nevada for the period 1915 to 1926 was 8.39 inches. That is, if the rainfall had been uniformly distributed, every spot of land in the State would have received this amount of moisture. However, the rainfall in Nevada is, of course, not uniform, but varies within wide limits. In general, the valleys receive much less and the mountains more than an average of 8.39 inches.

The altitude of the valleys in the northern and eastern sections of the State ranges from 4,000 to 5,000 feet, and these valleys receive an average of about six inches of rainfall per year. The valleys in the southeastern section are lower and somewhat drier. Las Vegas, at an altitude of 2,000 feet, has an average of 4.82 inches of rainfall, while Logandale, at an altitude of about 1,600 feet, receives about 5.84 inches per year.

The total annual precipitation increases progressively with elevation, though the rate of increase is not uniform in the various sections of the State, and in any area rather wide variations may occur in the total precipitation at different stations at the same elevation. Storms occur more frequently in certain localities than in others. This is especially true of the summer thunder storms.

L. H. Taylor, in the course of a study of the water supply of the Truckee River basin, tabulated the progressive increase in rainfall from the lowest station in point of elevation to the highest points on the Sierra Nevada for which weather records were available. His study showed the average increase in precipitation for each 100 feet rise in elevation to be 1.28 inches. This figure is probably accurate for a considerable extent of the Sierra Nevada range, but cannot be used in estimating the precipitation for other sections of the State.

W. O. Clark and C. W. Riddell in estimating the underground water supply of the Steptoe Valley in White Pine County assembled the weather records from 17 stations in Elko and White Pine Counties. When arranged according to altitudes these stations show a fairly regular increase in precipitation with increasing elevations. The factor of increase, or rate of increase for each 100 feet of rise in elevation, was calculated by the writer to be about 0.45 inches. The elevations of these stations ranged from 4,812 to 7,977 feet. It is probable that this factor will be found to give comparatively accurate results in estimating the precipitation for the areas represented by these stations. It may, in fact, be applicable to the entire northern and eastern part of Nevada east of the Sierra.

In the southeastern part of the State the precipitation averages slightly less than in the other districts. Moreover, at elevations below 6,000 feet there appears to be little if any local difference in precipitation due to elevation. Above 6,000 feet there are no existing records upon which to base an estimate of increases due to altitude. However, there is ample evidence in increased plant growth, springs, streams, and heavy snowfall to show that there is material increase in precipitation with increases in elevation above 6,000 feet. In the absence of records upon which to base an estimate of this increase for southeastern Nevada the factor determined for the northeastern section of

0.45 inches increase for each 100 feet rise in elevation may be considered applicable. If six inches is taken as the average precipitation at an elevation of 6,000 feet the factor of 0.45 inches gives a total rainfall of 18.5 inches at 9,000 feet, which does not appear improbable.

Storms may occur during any month of the year in Nevada, but most of the year's total precipitation comes during the winter months. November, December, January, and February are the months of relatively heavy precipitation. In the mountains, summer storms are of real value for they often serve to replenish the moisture supply and to cause springs and streams to flow with renewed vigor. The summer showers that fall over the valleys are often more detrimental than useful. Frequently the total rainfall in such a shower is too slight to wet more than the surface of the ground, thus causing the soil to crust and bake. Even when the rainfall is heavy enough to wet the soil to a useful depth, then as often as not it comes as a torrential downpour which rushes over the surface with little opportunity for absorption.

UNDERGROUND WATER

There is no mystery about the supply of underground water in the desert valleys of Nevada. It must all come from the precipitation that falls in the form of rain or snow. Also, this supply is subject to the same losses as surface waters, although the losses take place at a much slower rate. Losses from surface waters may be divided into four parts: run-off, evaporation, transpiration, and deep percolation, the latter being the part of the total rainfall that enters into the underground channels and forms the ground water supply.

Although not subject to evaporation or transpiration losses while in the deep channels, the underground water does have outlets and hence a run-off loss. These outlets may be springs, streams, lakes, swamps or merely wet lands where evaporation from the moist surface of the ground and the transpiration from the growing plans afford the outlet. If no such outlets existed, then the yearly increase in the water stored in the underground reservoirs would in time fill them to overflowing; and the water would appear on the surface. Then, instead of our interior valleys containing dry lakes, real lakes would again appear.

If the annual rainfall over the State were 40 inches instead of 8.39 inches, this condition would obtain and Nevada would be dotted with innumerable bodies of water.

The exact percentage of the rainfall that penetrates deeply enough into the soil to be lost to the surface and thus to become part of the underground water supply is variable and depends upon such factors as the topography or character of the surface of the ground, the texture and depth of the soil cover, and the amount and distribution of the rainfall.

Over a considerable part of Nevada the topographic conditions are favorable for the accumulation of underground water. The narrow, flat valleys filled with deep, rather loose sediments and surrounded by barren, precipitous mountains afford ideal conditions for the catchment of a large part of the run-off. Moreover, along the bases of the mountain ranges there are long alluvial fans of coarse sediments ideally situated to absorb the run-off.

A Section of the Spring Mountain Watershed in May. Only in years of exceptionally high precipitation do the streams from these mountains reach beyond the line of timber in the foreground; usually all the water is absorbed by the porous, alluvial slopes.

Mt. Charleston, near Las Vegas, Nevada. Elevation, 11,910 feet. Snow capped mountains furnish the water supply for the irrigated valleys.

The more open and porous is the soil cover, the easier it is for water to pass through to the underlying strata beyond the reach of the plant roots. Likewise, the thinner the soil cover the less water is required to satisfy its moisture-holding capacity, and the greater is the part of the total precipitation available for deep percolation. In some cases, however, the top layer of soil, while very shallow, is so impervious that little water can pass through and the surface run-off is then very large. This is true of some areas in southern Nevada where the rather violent summer showers are largely lost in surface run-off.

The quantity of the growth of the native vegetation depends primarily upon the moisture supply, which in its turn depends upon the total amount and distribution of the rainfall and the depth of the soil and its capacity for holding moisture. If all the surface of the ground in Nevada were covered with a soil of sufficient depth and moisture-holding capacity to absorb and hold all the water that falls upon it, there would be few spots where the growth of the native vegetation possible under those conditions would not use up practically all the average annual precipitation, leaving little for deep percolation and underground storage. However, the 50 to 60 per cent of the land surface which is composed of precipitous, nearly barren mountains and steep, gravelly, alluvial slopes cannot hold the water that falls on it and a considerable part passes downward through the loose surface and escapes to the lower lands to accumulate there as ground water. Since rainfall increases rapidly with an increase in elevation, the largest quantity of water falls on the area of land that is least able to retain the moisture.

The Long, Dry, Gravelly Alluvial Slopes Border the High Mountains. These slopes absorb practically all the direct precipitation and a great deal of the run-off from the mountains. A scene near Johnnie, Nevada.

A considerable part of the summer precipitation occurs in the form of rather heavy downpours and thunder storms in which the amount of water lost from the steep mountain slopes is very great. Even the winter snows melt rather rapidly in the spring and the run-off is large. Under these conditions, full opportunity for the soil to absorb and hold the rainfall and for the native vegetation to use it is not given and the surplus water flows down to the lower slopes and to valley floors. It is this concentration of the total rainfall in comparatively small areas that makes possible a relatively large amount of underground storage in a region of extremely scanty precipitation. The probability of concentration of the ground waters from a large territory into a small area is a factor that cannot be overlooked in estimating the water supply of any locality. Other factors are the area of

the drainage or catchment basin and the ratio of high mountain surface to valley area.

Underground waters may be compared to aboveground waters in practically all respects. They are nearly always in motion; and, though the rate of flow is much slower than that of the surface waters, it is none the less certain. Occasionally these waters move as wide sheets of slowly percolating moisture but more often the flow follows rather well-defined channels. These channels are sometimes closely associated with the surface stream or dry-wash channels; but in valleys with deep sediments or where the strata have been much disturbed, the underground channels may have no traceable relationship to the surface streams. The underground flows are often checked by dykes or other obstructions, thus forming subterranean reservoirs or lakes. These reservoirs are found especially along the margins of dry lakes where the waters are forced to the surface by the increased density of the sediments toward the centers of the valleys. Evidence of these reservoirs is seen in springs, seeps, damp ground, or a heavier growth of native vegetation than is usually found in the region.

To maintain a constant supply of water in the underground streams and reservoirs the amount of water flowing into them must equal the amount flowing out, since every such subterranean stream or lake has an outlet. This outlet may be in the form of springs or flowing wells, seepages, wet land, or marshes that are visible, or may sometimes occur as seepages into streams or as springs so far removed from their sources that the connection can scarcely be traced. Where such surface indications are not seen, the outlet may be through crevices in the underlying rocks of the valley into areas of lower elevation. In any case, whether apparent or hidden, the outlet must be present. Development by artesian wells or pumping wells consists of diverting the flow from the original or natural outlet into another which offers less resistance to the flow of water. Pumping is equivalent to providing a new and lower outlet with a consequent freer flow of the water to the pump than to the usual outlet.

In the case of a reservoir above ground, if more water is withdrawn than is replaced by inflow the reservoir will go dry, and the process will be visible and apparent. With underground waters a failing supply is made evident by a falling water table, or a lessening flow in the case of springs and artesian wells. Moreover, it should be remembered that the sources of supply of underground water are subject to the same seasonal and periodic variations in precipitation as the surface waters and tend to vary in the same manner, though the changes are less abrupt.

INDICATORS OF UNDERGROUND WATERS

When any considerable amount of underground water exists in any particular place there is always some visible evidence of its existence. In the case of a sheet or underground reservoir, if it is close enough to the surface to be tapped and pumped its presence will be indicated by the growth and the character of the native vegetation.

Salt grass and alkali crusts on the surface indicate a high water

table, usually within a few feet of the surface. Rabbit brush, the false goldenrod, grows where the water is down a few feet below the surface, but still quite close. Greasewood indicates a high water table, but grows over a wider range than the other plants mentioned. The author has seen greasewood growing on alkali flats where the water table varied from a few inches below the surface after storms to ten to twelve feet during the dry period. Mesquite often indicates a seepage, though many times it merely shows an area of deeper soil where sufficient surface waters are collected and absorbed to support a growth of shrubs or trees. An estimate of the probable quantity of underground flow can be made from the area covered by the growth of the indicator plants just described; an extensive area indicating a strong underflow, a small area indicating a light underflow. In making this estimate the average temperature of the region must be considered, as well as the area from which evaporation is taking place.

Springs and water mounds that occur in the axes of the valleys or near the valley floors are, aside from the visible flows, good indicators of ground water at a shallow depth. Their presence near the valley floors means that the reservoirs under these valleys are filled and some of the water is escaping through the springs. The absence of springs does not always mean that ground water is not present at shallow depths, but does mean either that the inflow into the reservoir is all used by evaporation from the ground surface and by transpiration from growing plants or else that there is an underground outlet through which the surplus waters are escaping. Under these conditions the water table or zone of entire saturation of the ground strata does not reach the surface. The complete absence of springs, wet lands, and water-indicating plants can usually be taken as proof that the water table at that particular place is quite low, probably below 50 feet, since the larger greasewood sends its roots down nearly that distance in search of water. However, there are cases of playas and dry lakes where the conditions of intermittent flooding and drying are so severe that plants cannot become established, and yet a water table may exist at reasonably shallow depths. In this case there is most surely an underground outlet through which the surplus waters are escaping. A well in such a location may yield a good supply of water in spite of the absence of the usual indications.

ARTESIAN WATER

Aside from the artesian water that has sufficient pressure or hydraulic head to cause it to rise to the surface and flow, the presence of artesian pressure is a vital factor in successful pumping from wells in many localities in Nevada. Artesian pressure causes the water to rise in a well from the depth at which it is encountered to various heights, depending on the amount of hydrostatic pressure present. In many cases where the water fails to come to the surface and flow, it still rises close enough to the surface to come within reach of a pump.

Several conditions are necessary for the creation of an artesian water supply. The water must have a relatively free entrance into the underground strata at a comparatively high elevation above the

valley floor, and the strata must be continuous, and open and porous enough to carry the stream without too great resistance. The first condition is found in ideal form at the foot of the steep mountain slopes where the streams emerge from the canyons upon the upper reaches of the stream-built fans. Here the material is nearly always of a gravelly nature, loose and porous, and able to absorb water freely. This is shown by the promptness with which many of our mountain streams, especially in the more arid sections of the State, disappear after reaching the tops of the alluvial fans. Also the material composing the fans is usually open enough to permit the passage of the water to its lower reaches. The second condition required for the creation of an artesian head is the presence of some obstruction to the free flow of the water through its underground channel.

In many of our enclosed valleys this obstruction results from the flattening of the grade of the fans as the distance from the mountains increases and the axis of the valley is approached. Since the fans are alluvial or water laid and are composed of material washed into the valleys by the mountain streams, the particles of material carried along by the water naturally become progressively smaller as the streams approach the flatter portions of the fan. Near the extreme ends of the fans the materials consist of only the finer particles of soil. Hence the material in the lower parts of the fans is finer grained and offers more resistance to the passage of water.

Two Flowing Wells in the Pahrump Valley. Artesian water often offers some puzzles. These two wells are each 375 feet deep, eight feet apart. They flow as is shown in the illustration.

This tends to check the flow of the underground water and to cause it to rise. If there is nothing present to check the upward rise of the waters as the grade flattens and the porosity decreases the water will reappear at the surface as seeps and springs or marshy land with little pressure on the water, usually near the center of the valley. However, if an obstruction exists to prevent the free rise of the water when it meets with resistance in its downward movement, the water will fill the understrata and rise until the pressure accumulated is sufficient to overcome the resistance to its upward movement. In the greater number of cases the obstruction is a layer of heavier and more impervious material which has been laid down over the coarser substance composing the fans. Such deposits could be formed only under water, hence only those of our interior valleys that once contained lakes now have artesian water.

The obstructing or impounding materials are variously efficient, according to the depth and composition of the layers, in preventing the rise of the ground waters. If the strata are thick, very impervious, and continuous there will be little leakage through them, and a comparatively large part of the inflow will be forced to the surface. If the inflow is large, the artesian pressure will be correspondingly high. On the other hand, if the impounding strata are weak and pervious, the pressure will be less. In any case the hydrostatic or artesian pressure will continue to increase until the resistance to the outflow of the incoming waters is overcome and a balance between the input and the output is struck. Under perfect artesian conditions it is possible for a very small stream to build up an immense artesian pressure.

There are several other conditions that operate to check the flow of water in the underground channels and to cause an artesian pressure to be built up. The water-bearing strata may pass under the valley floor and rise on the opposite side, intrusive dykes may cut the water streams, a bend or twist in the gravel beds may act as an obstruction, and occasionally a slip or fault may elevate the water bearing beds until they come opposite impervious strata so that the flow is checked. Usually the obstructions do not form perfect dams to the underground streams, and the flows, instead of being entirely checked, are merely impeded and part of the water continues to escape through the deep channels. The bedrock under the valleys is not ordinarily entirely water-tight and some of the water escapes by deep percolation through seams and crevices in the bedding material.

Since some losses are inevitable under artesian conditions it follows that only a part of the total supply of underground water can be recovered through flowing wells. If more wells are drilled than can be supplied by the recoverable part of the water, then all the wells in the district will decrease in yield. Hence, if it is desired to retain flowing wells in an artesian district, it must not be overdeveloped. A close check should be kept on the yield of the wells in the district and when a distinct reduction in flow is noted further drilling should cease. Moreover, the water should never be wasted; for such waste merely depletes the supply without benefit. It should be compulsory to close the wells when not in use, and the proper casing should be installed to insure tight wells whose flow can be shut off when it is not being used in irrigation.

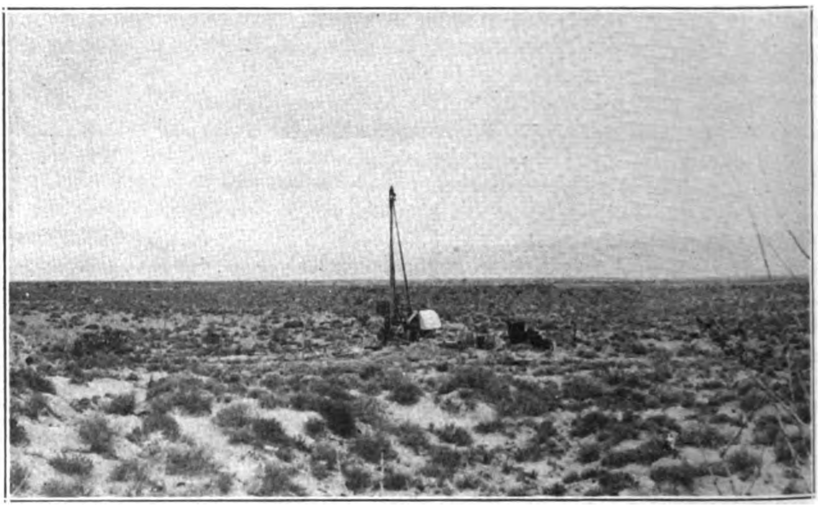
Pumping from an artesian supply is entirely feasible and serves a double purpose. More water can be secured from the wells, and the head or pressure on the artesian water within the limits of the influence of the wells is lowered by the depth to which the pumps drop the water in the wells. This lessened pressure means reduced losses of water through the natural outlets and a consequent greater available supply in the district.

Some precautions should be observed in pumping from artesian wells. If the formation is soft and inclined to cave, the casing should reach very nearly to the bottom of the well, leaving only the last flow free to enter the open bottom of the casing. In case other flows are cut off by the casing it can be perforated to admit these after being set in position. In hard formations it may not be necessary to use much casing.

DRILLING

Before deciding to put down a well a thorough study should be made of the water conditions, the extent of the drainage area that might be contributory to the proposed well, the character of the ground through which the well must be driven, the depth to the water table, the quality of the water, and the nature of the soil on which it is proposed to use the water.

The last is a primary consideration, particularly so because much of the soil in the valleys where the water is close to the surface contains such large quantities of alkali as to render it unfit for agricultural purposes. For those areas covered by the reports of the U. S. Geological Survey in the Water Supply Papers very complete information on all these factors can be found and these papers should be consulted by parties interested in well development work. A list of the Water Supply Papers that cover parts of the State of Nevada will be



A New Farm, the Beginning. The first step in conquering the desert is the development of an adequate supply of water.

found at the end of this bulletin. Certain areas in the same region have been mapped by the U. S. Bureau of Soils. In the Soil Reports detailed information is given regarding the soils, their nature, alkali content, and their suitability for various crops.

The quality of the water for irrigation or domestic use is of such importance that it deserves special consideration. If there are springs or wells in the vicinity of any contemplated development, the quality of the waters from these sources should be considered because they are at least an indication of what may be expected. However, there are often wide variations in the quality of waters from different springs and wells within narrow territorial limits, and the fact that good water is known to exist within a district should not be taken as absolute proof that new supplies will prove equally pure.

It sometimes happens that little or nothing can be done to determine the quality of a water supply before drilling. In such cases the water

should be analyzed as soon as possible after sinking the well and its fitness for use determined before undertaking any additional agricultural development.

When, after due consideration of all the factors concerning the water supply, the location for a well has been determined, the next question is the size of the proposed well and the method of sinking. If the water table is quite close to the surface and the water-bearing strata are also close, it may be feasible and economical to sink a shaft or pit. Usually this will require timbering to make it safe, and when water is encountered some method must be provided to handle it as it comes into the hole. If the supply is at all ample, a pump must be installed. This is always somewhat expensive and necessitates an estimate of the quantity of water the well may produce when finished and the securing of a pump to handle the estimated quantity. If the pump installed is of too small capacity to handle all the water it will be difficult to continue the work of sinking the shaft; and if a pump of ample capacity is secured, it may prove larger than is necessary after the work is completed. However, in case the estimates happen to be accurate and the pump large enough to handle the water while sinking the well and not too large for the supply after the work is completed, it may be that the well and the pump can stand as they are and the outfit be considered complete without further work. This happens so seldom that the method cannot be recommended. In this connection it must be remembered that very shallow wells quite often yield much more water when first dug than they will when pumped continuously for a considerable length of time; hence the pumping equipment that is necessary during sinking may prove more than ample for continuous operation.

Generally it will prove more satisfactory and economical to use a drilling outfit in putting down wells. If the territory is new and there are no wells to serve as guides, a spudding or percussion rig with solid tools is the safest to start with. A jet rig in which water is pumped through iron pipes forming the drill stem to outlets just back of the cutting edge of the bit is an excellent outfit for putting down small holes in exploratory work. The water returning to the surface outside the drill stem carries the material loosened by the bit, so but little bailing is necessary. Also, the mud from the hole itself is forced into the material forming the sides of the hole, making a rather effective plaster. This rig will readily handle stiff clays, cemented sands and gravels and soft rock such as the cemented materials and limstones found in lake beds; but it is not so good for hard rock or loose gravel. It is not difficult to convert any standard percussion rig into a jet rig and the attachment is extremely valuable. A mud scow, which is a heavy bailer with a cutting edge, is probably the best tool for sinking large holes in the average sedimentary material found in alluvial plains and lake beds. It is not so efficient in sinking wells of the smaller sizes. The rotary type of drill has been used successfully where deep beds of clays must be penetrated and the water-bearing beds are widely separated, but does not lend itself so readily to pioneering as the other types of drills. It is most successfully used with the very large holes such as the oil wells.

The cost of drilling will naturally vary with the distance from railroads and highways; but at the present time (1927) it ranges from $1

to $2 per foot for the first 200 feet of hole, with slight increases for each 100 feet below this depth. The larger the hole the higher the drilling cost. Casing costs from around fifty cents a foot for 4-inch standard screw casing to about $1 a foot for standard 8-inch screw casing. It may not be necessary to case a well to its entire depth; but it will usually prove best to have enough casing on hand to go to the bottom of the hole in the event that it proves necessary. In a flowing well or artesian area screw-joint casing only should be used, because it is only with this type of casing that an absolutely tight well can be obtained. For pumping wells where the water in the hole does not rise above the ground water level the double stovepipe casing is satisfactory. It is a convenient form of casing, for the short lengths lend themselves readily to handling by hand, but they cannot be driven as much as the screw casing. In hard formations or in gravel and sand that pack around the casing it is usually necessary to use jacks to force this type of casing down.

PERFORATING OR SCREENING

In any well of even moderate depth more than one water-bearing stratum or bed of gravel or sand will usually be encountered. While drilling is in progress, an exact log of the depth at which each water stratum is encountered should be kept. After the casing has been set in place without regard to the water beds, it should be perforated at each water-bearing stratum shown in the log. The perforations should be numerous enough and large enough to admit all the water into the casing that is carried by each water-bearing bed. In this respect the stovepipe casing is possibly slightly superior to the screw casing, perforating a little more readily. Under some circumstances where sufficient wells have been sunk to give fairly exact information concerning the depth of the different water-bearing strata, it is sometimes practical to use factory perforated screen casing. This casing can be obtained with a very large percentage of opening, which insures a free passage of the water into the well and prevents sealing of the screen by the accumulation of gravel and fine material in the perforations. It has the disadvantage of weakness and does not stand driving very well. Also the cost, except when placed according to accurate logs, is against its use.

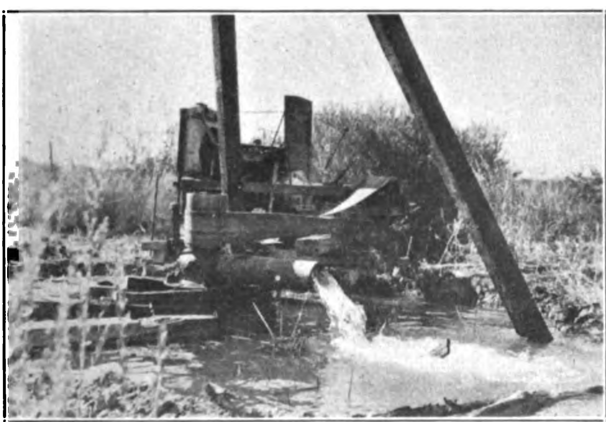
SIZE OF WELL

In prospecting for water in an unknown territory the size of the well should be kept as small as it is practicable to sink. The cost of sinking a 4-inch hole is not great; and yet, when properly perforated, this size will permit the entrance of water freely enough to give a fair indication of the quantity of the water in the material penetrated. The cost of casing and drilling is lower, and the chance of salvaging the casing in case of failure to find water is at least as good as with the larger wells. It is not as good for very deep holes, because the opportunity to reduce the size of the hole in the event that the casing becomes stuck is naturally much poorer. A 6-inch hole reduced to 4 inches after the first 100 feet offers a very good chance for both drilling and testing, since the cost is comparatively low and pumps of the deep well type that will enter a casing of this size are available with capacities

of about 30 inches of water. Another good combination is a section of 8-inch casing from the surface to about 100 feet with reduction to 6-inch, and for depths below 500 feet a further reduction to 4 inches.

This system of drilling may require several lines of casing during the drilling, but the inside lines are readily removed after the well has been completed. A well pump that goes inside an 8-inch casing has been used for testing artesian conditions in southern Nevada, and has been entirely satisfactory. It has a capacity at normal speeds of about 1 second-foot, but by overspeeding has been made to yield 50% more than this amount.

Such small wells as those described above could not be expected to be successful unless the water entered under considerable artesian pressure and issued from material of sufficiently coarse texture to permit a free flow. Where the water-bearing beds are of fine material that yields up its water slowly, wells of larger diameter are required to give the necessary area for the entrance of the water. However, in many areas in Nevada where development by pumping may be expected to be successful the conditions for good yields from wells of small diameter are present; that is, the water-bearing beds are relatively coarse, and the water exists under a considerable pressure.



A Successful Pump Test. The picture at the top of the page shows the natural flow of the well, while the lower one shows the flow that was developed with a 50 foot drawdown.

WELL TESTING

After a well has been dug or drilled it should be tested by pumping for a sufficient length of time to determine rather accurately the yield

of the well, the drawdown when pumping, and the time taken for the well to recover after pumping ceases. From this information it is possible to tell whether or not the well produces enough water within reasonable drawdown limits to be worth developing. In starting the test of a drilled well the pump should be run at slow speed until the water begins to clear up. The speed should then be increased until the water again becomes muddy, and run at this speed until the well clears again. This process should be repeated until the maximum capacity of the pump or well is reached. It often helps in clearing the mud and sand from a well to run the pump at full capacity until the drawdown is at the maximum and then suddenly stop the pump, allowing the water in the pump and pipe to drop into the well. This causes a surging action that loosens the fine materials near the casing and causes them to drop into the well. This process is repeated several times or until it no longer causes the well to become muddy. This leads to the development of small channels which bring water to the well; and it may increase the capacity of the well materially.

A Pump Test That Failed. This well gave but very little more water than the original flow, even when pumped to a depth of 70 feet.

The information secured from the pump test likewise affords a means of selecting the proper type and size of pump for the well in question. If the owner is in doubt after the test has been made as to the pump that will be required, the test data can be submitted to any reliable pump manufacturing company, and expert advice obtained concerning the type and capacity of pump required. It seems scarcely needful to state that the pumping equipment should not be purchased before a thorough test of the well has been made. Too large a pump for the supply of water means uneconomical operation, while too small an outfit does not permit using the source of the water supply to its full capacity.

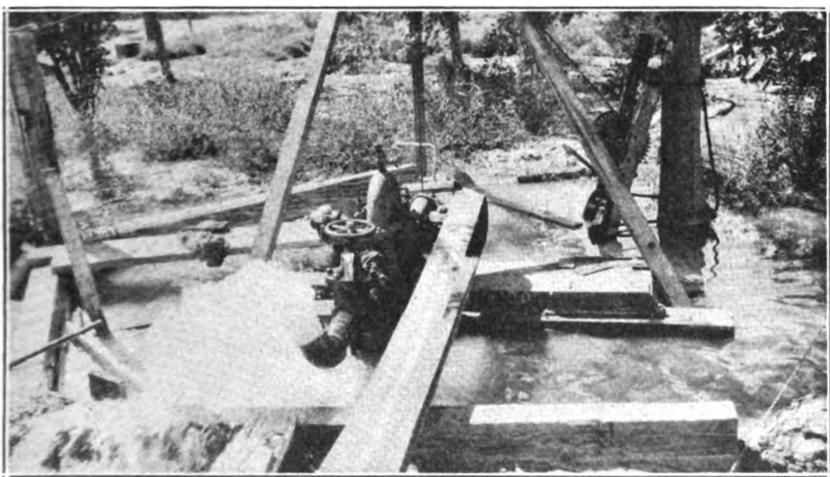
In cooperation with the Division of Agricultural Engineering, U. S. Bureau of Public Roads, the Nevada Agricultural Experiment Station has made a large number of pumping tests on wells as a part of the study of the water supply of the Las Vegas Valley in southern Nevada. The results of some of these tests are given in the Table No. 1. Note that in some cases pumping caused an increase in the natural or artesian flow while in others it did not, also that some wells developed, or gave progressive increase, while pumping, and others changed very little under test. The table follows:

TABLE I
Well Tests in the Las Vegas Valley

Name of well	Natural flow		Quantity pumped		Draw-down
	Before pumping sec. ft.	After-pumping sec. ft.	Beginning of test sec. ft.	Ending of test sec. ft.	
J. J. Cannon	0.09	0.26	0.95	1.07	40'
Densmore	0.08	0.197	0.80	0.89	52'
Mark Blake	0.197	0.20	0.65	0.65	40'
C. M. Owens	0.052	0.052	0.19	0.19	20'
Ira McFarland			0.46	0.46	70'
J. M. Heaton	[1]5	[1]5	[1]22	[1]22	68'

[1] Gallons per minute.

The first four wells in the table gave increases that were great enough to justify the expense involved in the purchase and operation of the



A Good Test With a Centrifugal Pump. The water in many of our pumping districts is close enough to the surface to permit the use of centrifugal pumps on the surface of the ground.

necessary pumping equipment. The last two failed to give sufficient water under pumping to be economical producers. Also, the first two wells evidently developed under pumping, showing a higher flow after the test than before, while the flow of others failed to increase.

The next table shows the results of a test typical of those carried out on these wells. The well on which this test was made had just been drilled to a depth of 352 feet. The water rose to within four feet of the surface, showing considerable artesian pressure, but it was not quite a flowing well. It was cased with 8-inch screw casing for the first two hundred feet, then with a short section of 6-inch, and was finished with 4-inch casing to the bottom. After clearing out the sand by pumping slowly for a time, then increasing the speed of the pump, and finally through surging, as described above, until the water came clear, a 24-hour test was made. In this test the pump was run at a speed

that gave a drawdown of about 33 feet and a discharge of approximately one second foot. The discharge was maintained at this rate very steadily with no drop in the drawdown, indicating an adequate quantity of water in the formation supplying the well. After the completion of the 24-hour run the following test was made:

TABLE 2
Pump Test of Kidder Well

Date	Draw-down	Quantity of water		Length of run
		Sec. ft.	Inches	
9-17-18	33	0.99	39.6	24 hours
9-18-18	10	0.34	13.6	10 minutes
	15	0.56	22.4	10 minutes
	20	0.62	24.8	15 minutes
	25	0.76	30.4	15 minutes
	30	0.88	35.2	20 minutes
	34	0.96	38.4	30 minutes
	40	1.13	45.2	30 minutes
	45	1.23	49.2	30 minutes
	50	1.32	52.8	40 minutes
	55	1.47	58.8	40 minutes

The information furnished by this test enabled the owner of this well to choose a pump of the type and capacity required for the quantity of water needed. The pump selected was a 3-inch horizontal centrifugal. This was set on a level with the top of the casing and gave a discharge of 0.68 second feet or 25.2 inches, indicating a drawdown of a little over 20 feet. It would be possible to develop more with this pump by placing it in a pit just above the water level, but for larger amounts and greater drawdown a deep well type of pump would probably prove more satisfactory.

Plunger Pump. The plunger type of pump has been in use for many years. It is efficient, being especially adapted to use with windmills, steam or gas engines. This type of pump finds its greatest use in elevating comparatively small quantities of water from wells of small diameter, especially when the water must be lifted a considerable distance. For lower lifts and larger quantities they are not as cheap to install as other types.

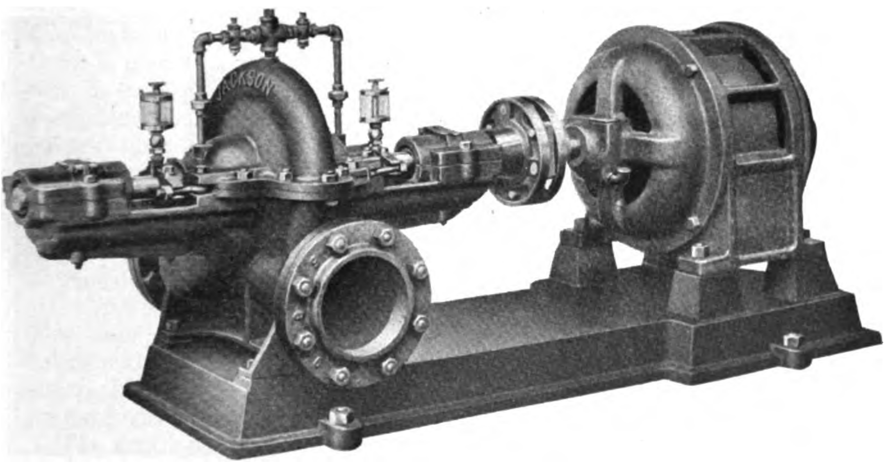
Centrifugal—Horizontal and Vertical. With the development of the gasoline engine there came a demand for a type of pump that could be operated readily with this source of power. As a result of this demand the centrifugal pump came into general use. This pump is very efficient and has a long life. It is belted directly to a gasoline engine or electric motor, is very light and easily installed for the quantity of water lifted, easily repaired, and cheap. These qualities have made it the favorite type of pump for lifting water wherever conditions permit its use. It is especially well adapted for use with electric power in that the pump and the motor can be directly connected, doing away with the necessity of belting. The extension of electric lines into the farming communities has already greatly increased the use and the popularity of this pump.

The centrifugal pump is made in either the horizontal or the vertical form and in a great variety of sizes and designs to meet almost any possible conditions under which water is to be lifted. The larger

pumps will lift water in single stages as high as 125 feet. The inability of the centrifugal pump to operate with a drawdown of more than 20 feet is not important where conditions permit placing the pump within this distance above the level of the water supply and the water level does not vary greatly. If the fluctuation in the water level be greater than 20 feet the operation of the horizontal centrifugal pump may be seriously interfered with.

Under such conditions the vertical type centrifugal may be used to advantage since with this type of pump the shaft can be extended to bring the belt pulley or motor above the water level, the pump itself operating under or above the water. The vertical centrifugal drive shaft must be supported by bearings spaced about six feet apart from the surface down to the pump. This adds to the expense of installing the pump, and when the pit is excessively deep the bearings are oiled with difficulty.

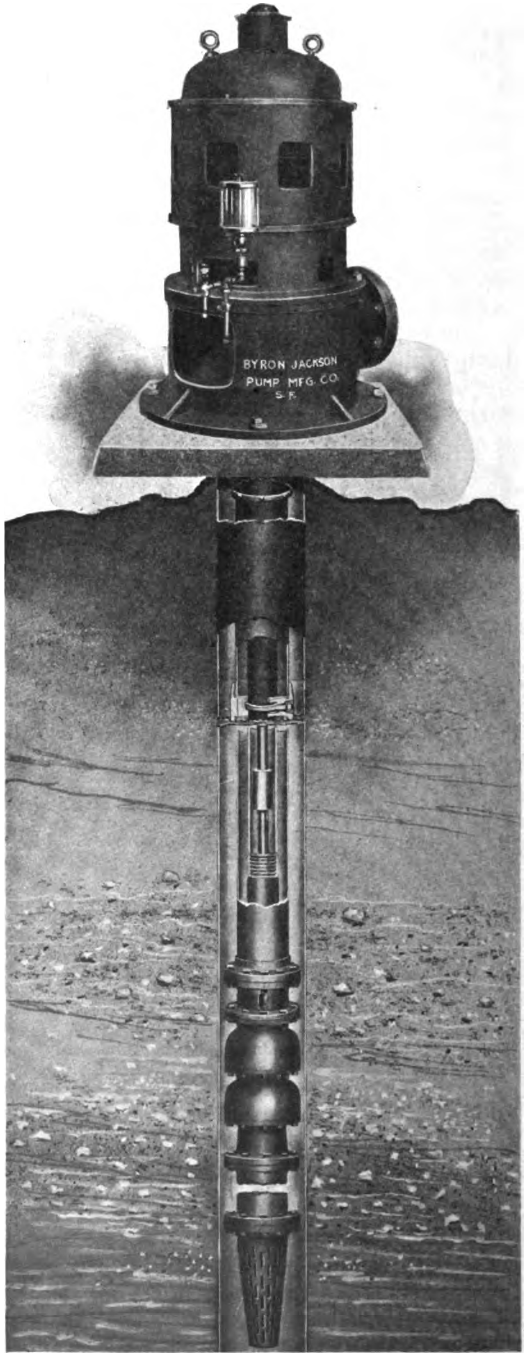
In order to bring the level of the water supply within the suction



Horizontal Type of Centrifugal Pump Direct-Connected to Electric Motor.
Courtesy of Byron Jackson Pump Co.

limit of the pump it is very often necessary to install the pump in a pit. This is no great obstacle so long as the pit is relatively shallow but it becomes increasingly serious with the increase in the depth of the pit. This is especially true if the pump must be located below the level of the ground water, in which case a water-tight compartment to contain the pump must be built, or else the vertical type of pump must be used.

Screw Pump. The efficiency of the centrifugal pump is highest when pumping against heads greater than 10 feet, the loss of efficiency being very rapid below this head. A new type of pump known as the screw pump has been designed to meet the need for a pump that will operate efficiently at the very low heads. This pump has a very high efficiency on heads from 2 to 10 feet, and where large quantities of water are to be handled at these heads, it replaces the centrifugal pump.



Deep Well Turbine. Courtesy Byron Jackson Pump Co.

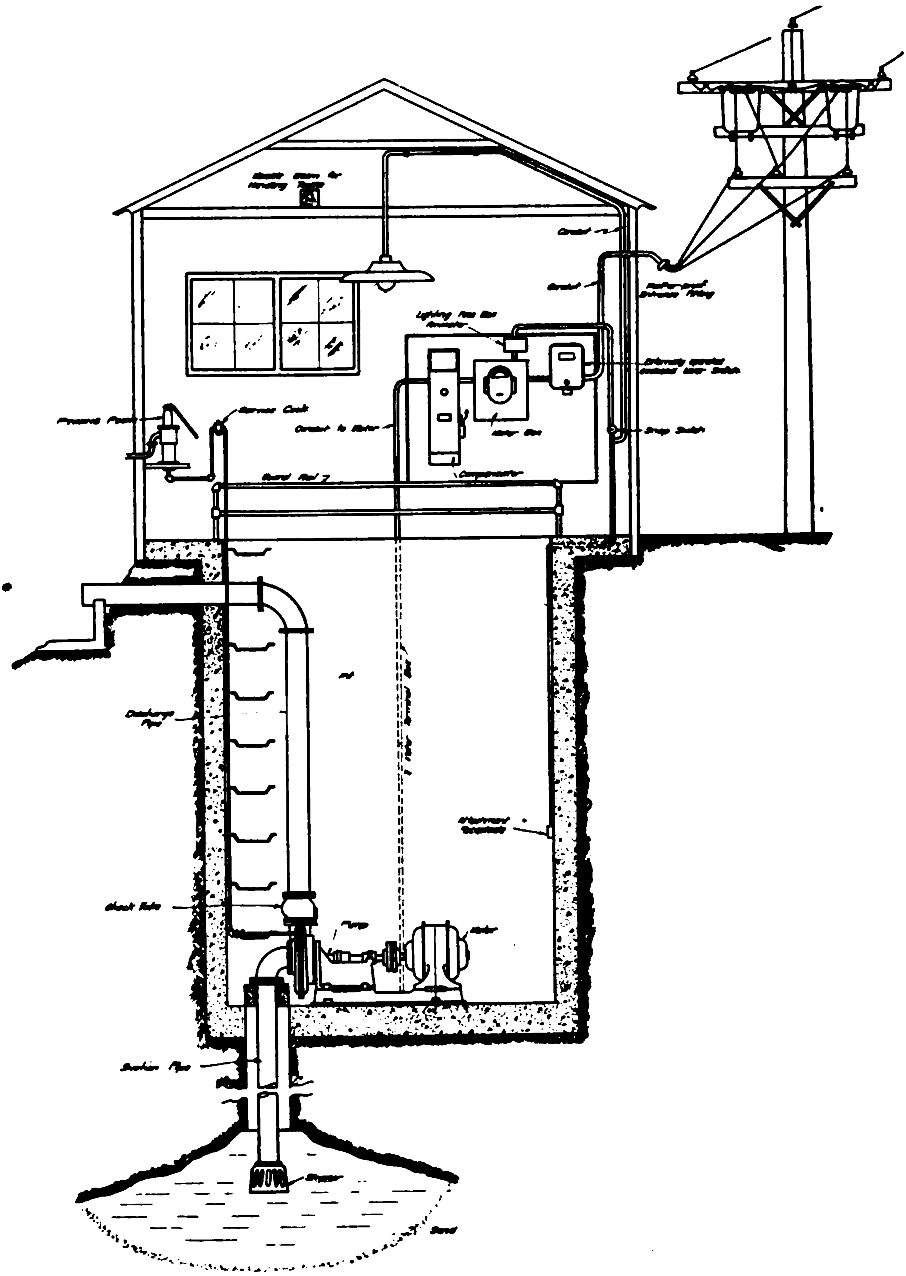
Deep Well Turbine. In some districts, although the depth to the water table is relatively great, the conditions of soil, climate, and markets will permit the lifting of water for irrigation purposes at a very high cost. Under these conditions none of the pumps described may quite meet the need. To reach the water at considerable depths, wells of small diameters from 4 to 18 inches are drilled. These wells are too small to allow the ordinary centrifugal pump to be placed within the casing. The depth to the water is so great that the cost of digging a pit to install the pump becomes excessive. Quite often the lowering of the water table after a few seasons' pumping makes it necessary to lower the pump, which in the case of a pump in a pit may involve a considerable expense. To meet these conditions a number of very efficient deep well pumps have been placed on the market.

These pumps are made in capacities from about 300 miners' inches to many hundreds of inches, and in sizes from those that will enter an eight-inch casing to those that require casing of 18 inches or larger. These pumps are readily installed, and since the power is applied at the surface, no pits are required. The first cost of a pump of this type is greater than that of a centrifugal pump of the same capacity, but in ease of installation they are much ahead, so that the cost of a completed plant under conditions that make this pump advisable may be considerably less than for the centrifugal pump. In the case of a falling water table it is quite easy to add additional sections of pump to reach the water at its lower level. In the amount of care and attention required during operation this pump compares very favorably with the centrifugal pump. In efficiency it is almost on a par with the centrifugal. It can be belted to any suitable source of power and is particularly well fitted for operation with a direct-connected motor. For ease in handling and setting up, the pump is made in sections from six to twelve feet long. In the matter of upkeep, the items of depreciation and repair are possibly slightly greater than for the centrifugal pump.

The depth from which the deep well pump will lift water depends on the length of the pump and the amount of power expended, the ordinary range lying between 40 and 200 feet.

The illustration shows a pump of this type in operation. In this case the pump is belted to a gasoline engine. Such an outfit, consisting of the engine and pump with fifty feet of pump bowls and pipe and 20 feet of suction pipe, can be set up in the field, ready to operate, in about five hours by two experienced men.

Air Lift Pumps. The air lift has numerous advantages in its favor, but its efficiency is so much lower than that of other types of pumps commonly used for lifting water that its field of usefulness is decidedly limited. Its chief advantage lies in the absence of complicated working parts below the surface of the ground. The air lift is adapted to lifting water from considerable depths. It is easily installed and operates well with a fluctuating water table. It is possible to install an air lift in a casing too crooked to receive a deep well turbine. It is also possible to operate a battery of air lifts on a series of wells, from a central compressor station.



Vertical Section of Pumphouse and Pit Showing Electric Control and Direct-Connected Horizontal Centrifugal Pump. Courtesy Byron Jackson Pump Co.

The absence of working parts below the surface of the ground makes the air lift particularly well fitted for handling water containing excessive quantities of silt and sand, and it is used extensively in cleaning wells and fitting new wells for the installation of other types of pumps.

The Siphon. It frequently happens that springs and flowing wells occur along the rims of lake terraces and fault lines at considerable elevations above the irrigable lands. If the slope of the ground from the source of the water to the land upon which the water is to be used is such that a fall of from 18 to 25 feet can be obtained within a reasonable distance, it is often possible and economically feasible to make use of siphons.

The siphon may be compared to a low lift suction pump. Theoretically the siphon under perfect conditions at sea level should have a suction or pull equivalent to atmospheric pressure, or 33 feet at 14.7 pounds per square inch of air pressure. Under actual working conditions at elevations of 2,500 feet or more, the lessened air pressure together with friction losses in the pipe lines serve to reduce the effective suction of a siphon to from 16 to 20 feet. Within these limits, however, the siphon is just as effective as a pump and serves the same purpose. To secure an effective siphon the discharge pipe should be as short as possible, and to reduce friction losses this line should be slightly larger than is necessary to carry the volume of water flowing through it. To maintain the suction of the siphon it is necessary to reduce the discharge end of the pipe line until the flow of water will completely fill the throttled end. It may further assist if the discharge end of the siphon is carried down below a permanent water level.

Priming a siphon is essentially the same process as priming a centrifugal pump. There should be a gate valve near the discharge end of the pipe line and an air valve at the highest point in the line. When installed in a spring or flowing well the pipe line should be so arranged that the natural flow is discharged through the siphon, in which case the priming is very conveniently done by closing the discharge gate valve, opening the air valve and allowing the natural flow to fill the pipe lines. Then the air valve is closed and the siphon is ready to operate upon the opening of the discharge gate valve. When the natural flow cannot be passed through the pipe lines the procedure is essentially the same except that a small hand pump is placed upon the air valve and the air exhausted from the pipe lines by pumping. The water will flow into the lines from the source of supply as fast as the air is exhausted so that when the air is all pumped out the pipe lines are full of water and the siphon is ready to operate. Siphons require frequent priming.

SELECTION OF PUMP

The selection of the type of pump must be based upon a study of the entire set of conditions under which the pump must operate. The size will depend on the quantity of water which is to be lifted; or, in the case of a limited supply, upon the quantity available. In the latter case it is usually advisable to make a preliminary test of the available supply and secure a pump adequate to handle it.

PUMP CAPACITIES

The following table shows the average capacity of various sizes of centrifugal pumps, together with their efficiencies and the horsepower per foot of lift required to operate each pump:

TABLE 3

Typical Capacities of Centrifugal Pumps and Horsepower Required for Their Operation Under Average Conditions.[1]

No. of centrifugal pump	Discharge per minute	Theoretical horsepower per foot of lift	Efficiency	Actual horsepower per foot of lift[2]	No. of centrifugal pump	Discharge per minute	Theoretical horsepower per foot of lift	Efficiency	Actual horsepower per foot of lift[2]
	U. S. gals.		*Per cent*			*U. S. gals.*		*Per cent*	
2	100	0.025	40 to 45	0.06	5	700	0.175	62 to 66	0.28
2½	150	.038	45 to 50	.08	6	900	.225	66 to 68	.34
3	225	.056	50 to 55	.11	7	1,200	.300	68 to 70	.44
3½	300	.075	55 to 60	.14	8	1,600	.400	70 to 74	.57
4	400	.100	60 to 62	.17					

[1] Above efficiencies are for pumps properly designed and installed for heads of 40 to 60 feet Plant efficiencies can be estimated by subtracting 10 per cent for direct-connected electric motors and 17 to 22 per cent for belt connected power.
[2] Efficiencies taken as the lower in preceding column.

This table is from U. S. Department of Agriculture Farmers Bulletin No. 1404, "Pumping from Wells for Irrigation."

The horsepower required to lift any quantity of water any specified distance may be obtained from the following formula:

$$\text{Horsepower} = \frac{\text{g.p.m.} \times \text{h}}{4{,}000 \times \text{E}}$$

Where g.p.m. = gallons pumped per minute.
h = total head in feet against which pump must work. This includes the total vertical lift plus frictional and other losses.
E = the efficiency of the pump.

An efficiency of 50% is usually assumed for any type or size of centrifugal pump, though the actual efficiency varies with the size of pump, and to some extent with the head against which the pump is operating.

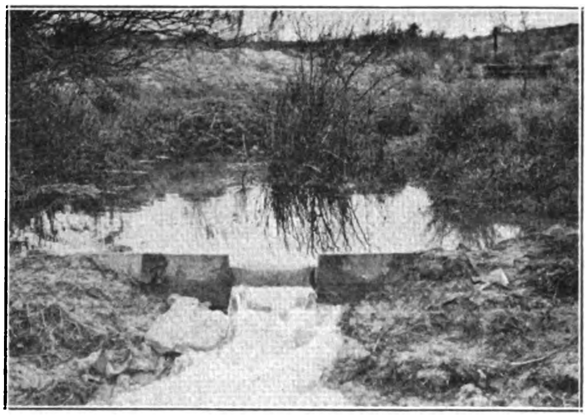
WEIRS AND WEIR TABLES

Three forms of weirs for measuring flowing streams are in common use. These are the rectangular, Cipolletti, and 90-degree V-notch. The first two are suitable, with the proper length of crest, for quantities of 12 inches of water or more. Below 12 inches the 90-degree V-notch which permits the accurate measurement of quantities as low as 2 inches, is recommended. This weir will also give accurate results with large streams, but since the head is higher for the same quantity and the consequent loss of fall in the ditch is greater than with either the rectangular or the Cipolletti weir, one of these is generally preferable for large streams.

The rectangular weir, as its name implies, has the sides of the notch at right angles to the crest, while the Cipolletti has the sloping sides in the ratio of 1 to 4. The 90-degree V-notch can be readily marked

out by the use of the steel square. The point of the square is placed on the face of the board to be cut at a point which is to be the bottom of the notch. The square is then set so that the same figures appear on the outside edges of both legs at the edge of the board. Lines for saw cuts are then drawn along the outside edges of the square. Then, if the top of the board is set level, the weir notch will be in proper position.

To secure accurate measurements, certain conditions must be complied with in making and setting any form of weir. The upstream edge of the weir crest should be straight and sharp and, if the notch is cut from a board, the downstream edges should be beveled at an angle of about 45 degrees. The edge of the crest may have a width of not more than one-fourth inch. If the weir is set in a bulkhead it must be flush with the face of the bulkhead and must not project beyond it. The weir or bulkhead should be vertical and at right angles to the stream.



A Very Good Field Setting of a Weir. Note the large weir pool, the vertical position of the bulkhead across the stream, and the free fall below the crest. The measuring peg is just above and to the right of the end of the axe handle.

The weir pool, or stilling pond above the weir, should be large enough to check completely the velocity of the water flowing into it, so that the water approaches the weir crest with no appreciable velocity. As usually given, the dimensions of a weir pool are such that the distance from the crest of the weir to the bottom of the pond must equal three times the depth of water flowing over the weir, and the distance from the sides of the crest to the bank should equal twice the depth flowing over the weir.

The free fall below the crest of the weir should be sufficient to permit a free circulation of air under the water below the crest.

When large heads of water are to be measured, a straight run of at least 50 feet in the ditch above the weir should be allowed. This distance may be less for very small quantities.

The depth of water flowing over the crest is called the head. It should be measured at a distance upstream approximately four times the head, or if the head be measured on the front of the weir or bulkhead the distance out from the edge of the weir should be at least two times the head. These distances are sufficient to get away from the "drawdown" or downward curving of the water as it passes over the first weir crest. A scale or gage for reading the head may be fastened

to the weir or bulkhead, or if the weir is placed in a box the gage may be secured to the side of the box. When no box is used a peg should be driven in the ditch bottom to an exact level with the crest. If the peg is driven a little below the level and a nail driven into the peg to the exact level the resulting measurements may be more accurate. A common ruler may be used to place on the nail head or peg and measure the head, but a small steel scale graduated into tenths and hundredths of a foot is more satisfactory. Care should be taken to read the scale with the eye as near the water surface as possible and to read the figures at the surface of the water and not at the edge of the wetted area on the rule.

The measured head is then referred to the proper weir table, and the quantity flowing is read in second feet directly from the table. The following abbreviated tables are intended to cover the usual quantities of water that might be pumped from wells in Nevada and are not intended for more general use. For a comprehensive discussion and extended weir tables refer to Farmers Bulletin 813, United States Department of Agriculture, from which these tables are taken:

TABLE 4

Discharge Tables for Rectangular Weirs

Computed from the formula $Q=3.247\,lH^{1.48}-\dfrac{0\ 566\,l^{1.8}}{1+2\,l^{1.8}}H^{1.9}$

Head in feet	Head in inches	Discharge in cubic feet per second for crests of various lengths					Head in feet	Head in inches	Discharge in cubic feet per second for crests of various lengths				
		1 foot	1.5 feet	2 feet	3 feet	4 feet			1 foot	1.5 feet	2 feet	3 feet	4 feet
0.20	$2\frac{3}{8}$	0.291	0.439	0.588	0.887	1.19	.53	$6\frac{3}{8}$	1.21	1.84	2.46	3.73	4.99
.21	$2\frac{1}{2}$	.312	.472	.632	.954	1.28	.54	$6\frac{1}{2}$	1.25	1.89	2.53	3.83	5.13
.22	$2\frac{5}{8}$	.335	.505	.677	1.02	1.37	.55	$6\frac{5}{8}$	1.28	1.94	2.60	3.94	5.27
.23	$2\frac{3}{4}$	.358	.539	.723	1.09	1.46	.56	$6\frac{3}{4}$	1.31	1.99	2.67	4.04	5.42
.24	$2\frac{7}{8}$	.380	.574	.769	1.16	1.55	.57	$6\frac{13}{16}$	1.35	2.04	2.74	4.15	5.56
.25	3	.404	.609	.817	1.23	1.65	.58	$6\frac{15}{16}$	1.38	2.09	2.81	4.26	5.70
.26	$3\frac{1}{8}$	.428	.646	.865	1.31	1.75	.59	$7\frac{1}{16}$	1.42	2.15	2.88	4.36	5.85
.27	$3\frac{1}{4}$	.452	.682	.914	1.38	1.85	.60	$7\frac{3}{16}$	1.45	2.20	2.96	4.47	6.00
.28	$3\frac{3}{8}$	.477	.720	.965	1.46	1.95	.61	$7\frac{5}{16}$	1.49	2.25	3.03	4.59	6.14
.29	$3\frac{1}{2}$	.502	.758	1.02	1.53	2.05	.62	$7\frac{7}{16}$	1.52	2.31	3.10	4.69	6.29
.30	$3\frac{5}{8}$	.527	.796	1.07	1.61	2.16	.63	$7\frac{9}{16}$	1.56	2.36	3.17	4.81	6.44
.31	$3\frac{3}{4}$	.553	.836	1.12	1.69	2.26	.64	$7\frac{11}{16}$	1.60	2.42	3.25	4.92	6.59
.32	$3\frac{13}{16}$	.580	.876	1.18	1.77	2.37	.65	$7\frac{13}{16}$	1.63	2.47	3.32	5.03	6.75
.33	$3\frac{15}{16}$	.606	.916	1.23	1.86	2.48	.66	$7\frac{15}{16}$	1.67	2.53	3.40	5.15	6.90
.34	$4\frac{1}{16}$	.634	.957	1.28	1.94	2.60	.67	$8\frac{1}{16}$	1.71	2.59	3.47	5.26	7.05
.35	$4\frac{3}{16}$	.661	.999	1.34	2.02	2.71	.68	$8\frac{3}{16}$	1.74	2.64	3.56	5.38	7.21
.36	$4\frac{5}{16}$	.688	1.04	1.40	2.11	2.82	.69	$8\frac{1}{4}$	1.78	2.70	3.63	5.49	7.36
.37	$4\frac{7}{16}$	.717	1.08	1.45	2.20	2.94	.70	$8\frac{3}{8}$	1.82	2.76	3.71	5.61	7.52
.38	$4\frac{9}{16}$	.745	1.13	1.51	2.28	3.06	.71	$8\frac{1}{2}$	1.86	2.81	3.78	5.73	7.68
.39	$4\frac{11}{16}$	.774	1.17	1.57	2.37	3.18	.72	$8\frac{5}{8}$	1.90	2.87	3.86	5.85	7.84
.40	$4\frac{13}{16}$	.804	1.21	1.63	2.46	3.30	.73	$8\frac{3}{4}$	1.93	2.93	3.94	5.97	8.00
.41	$4\frac{15}{16}$	.833	1.26	1.69	2.55	3.42	.74	$8\frac{7}{8}$	1.97	2.99	4.02	6.09	8.17
.42	$5\frac{1}{16}$	.863	1.30	1.75	2.65	3.54	.75	9	2.01	3.05	4.10	6.21	8.33
.43	$5\frac{3}{16}$	.893	1.35	1.81	2.74	3.67	.76	$9\frac{1}{8}$	2.05	3.11	4.18	6.33	8.49
.44	$5\frac{1}{4}$	.924	1.40	1.88	2.83	3.80	.77	$9\frac{1}{4}$	2.09	3.17	4.26	6.45	8.66
.45	$5\frac{3}{8}$	.955	1.44	1.94	2.93	3.93	.78	$9\frac{3}{8}$	2.13	3.23	4.34	6.58	8.82
.46	$5\frac{1}{2}$	.986	1.49	2.00	3.03	4.05	.79	$9\frac{1}{2}$	2.17	3.29	4.42	6.70	8.99
.47	$5\frac{5}{8}$	1.02	1.54	2.07	3.12	4.18	.80	$9\frac{5}{8}$	2.21	3.35	4.51	6.83	9.16
.48	$5\frac{3}{4}$	1.05	1.59	2.13	3.22	4.32	.81	$9\frac{3}{4}$	2.25	3.41	4.59	6.96	9.33
.49	$5\frac{7}{8}$	1.08	1.64	2.20	3.32	4.45	.82	$9\frac{13}{16}$	2.29	3.47	4.67	7.08	9.50
.50	6	1.11	1.68	2.26	3.42	4.58	.83	$9\frac{15}{16}$	2.33	3.54	4.75	7.21	9.67
.51	$6\frac{1}{8}$	1.15	1.73	2.33	3.52	4.72	.84	$10\frac{1}{16}$	2.37	3.60	4.84	7.33	9.84
.52	$6\frac{1}{4}$	1.18	1.78	2.40	3.62	4.86	.85	$10\frac{3}{16}$	2.41	3.66	4.92	7.46	10.01

TABLE 5

Discharge Tables for Cipolletti Weirs

Computed from the formula $Q=3.247\,lH^{1.48}-\dfrac{0.566\,l^{1.8}}{1+2\,l^{1.8}}H^{1.9}+0.609\,H^{2.5}$

Head in feet	Head in inches	Discharge in cubic feet per second for crests of various lengths					Head in feet	Head in inches	Discharge in cubic feet per second for crests of various lengths				
		1 foot	1.5 feet	2 feet	3 feet	4 feet			1 foot	1.5 feet	2 feet	3 feet	4 feet
0.20	2 3/8	0.30	0.45	0.60	0.90	1.20	.53	6 3/8	1.34	1.96	2.59	3.85	5.12
.21	2 1/2	.32	.48	.64	.97	1.29	.54	6 1/2	1.38	2.02	2.66	3.96	5.26
.22	2 5/8	.35	.52	.69	1.04	1.38	.55	6 5/8	1.42	2.07	2.74	4.07	5.41
.23	2 3/4	.37	.55	.74	1.11	1.47	.56	6 3/4	1.46	2.13	2.81	4.18	5.56
.24	2 7/8	.39	.59	.79	1.18	1.57	.57	6 13/16	1.50	2.19	2.89	4.30	5.71
.25	3	.42	.63	.84	1.25	1.67	.58	6 15/16	1.54	2.25	2.97	4.41	5.86
.26	3 1/8	.45	.67	.89	1.33	1.77	.59	7 1/16	1.58	2.31	3.05	4.53	6.01
.27	3 1/4	.47	.70	.94	1.40	1.87	.60	7 3/16	1.62	2.37	3.13	4.64	6.17
.28	3 3/8	.50	.74	.99	1.48	1.97	.61	7 5/16	1.67	2.43	3.20	4.76	6.32
.29	3 1/2	.53	.79	1.04	1.56	2.08	.62	7 7/16	1.71	2.49	3.28	4.88	6.47
.30	3 5/8	.56	.83	1.10	1.64	2.19	.63	7 9/16	1.75	2.55	3.37	5.00	6.63
.31	3 3/4	.59	.87	1.15	1.73	2.30	.64	7 11/16	1.80	2.62	3.45	5.12	6.79
.32	3 13/16	.61	.91	1.21	1.80	2.41	.65	7 13/16	1.84	2.68	3.53	5.24	6.95
.33	3 15/16	.64	.95	1.27	1.89	2.52	.66	7 15/16	1.89	2.75	3.61	5.36	7.11
.34	4 1/16	.67	1.00	1.32	1.98	2.64	.67	8 1/16	1.93	2.81	3.70	5.48	7.28
.35	4 3/16	.70	1.04	1.38	2.07	2.75	.68	8 3/16	1.98	2.87	3.79	5.61	7.44
.36	4 5/16	.73	1.09	1.44	2.16	2.87	.69	8 1/4	2.02	2.94	3.87	5.73	7.61
.37	4 7/16	.77	1.13	1.50	2.25	2.99	.70	8 3/8	2.07	3.01	3.95	5.86	7.77
.38	4 9/16	.80	1.18	1.57	2.34	3.11	.71	8 1/2	2.12	3.07	4.04	5.99	7.94
.39	4 11/16	.83	1.23	1.63	2.43	3.24	.72	3 5/8	2.16	3.14	4.13	6.12	8.11
.40	4 13/16	.87	1.28	1.69	2.53	3.36	.73	8 3/4	2.21	3.21	4.22	6.24	8.28
.41	4 15/16	.90	1.32	1.76	2.62	3.49	.74	8 7/8	2.26	3.28	4.31	6.38	8.45
.42	5 1/16	.93	1.37	1.82	2.72	3.61	.75	9	2.31	3.35	4.40	6.51	8.62
.43	5 3/16	.97	1.42	1.89	2.81	3.74	.76	9 1/8	2.36	3.42	4.49	6.64	8.80
.44	5 1/4	1.00	1.47	1.95	2.91	3.87	.77	9 1/4	2.41	3.49	4.58	6.77	8.97
.45	5 3/8	1.04	1.53	2.02	3.01	4.01	.78	9 3/8	2.46	3.56	4.67	6.90	9.15
.46	5 1/2	1.07	1.58	2.09	3.11	4.14	.79	9 1/2	2.51	3.63	4.76	7.04	9.33
.47	5 5/8	1.11	1.63	2.16	3.21	4.28	.80	9 5/8	2.56	3.70	4.85	7.18	9.51
.48	5 3/4	1.15	1.68	2.23	3.32	4.41	.81	9 3/4	2.61	3.77	4.95	7.31	9.69
.49	5 7/8	1.18	1.74	2.30	3.42	4.55	.82	9 13/16	2.66	3.84	5.04	7.45	9.87
.50	6	1.22	1.79	2.37	3.53	4.69	.83	9 15/16	2.71	3.92	5.14	7.59	10.05
.51	6 1/8	1.26	1.85	2.44	3.64	4.83	.84	10 1/16	2.77	3.99	5.23	7.73	10.23
.52	6 1/4	1.30	1.90	2.51	3.74	4.97	.85	10 3/16	2.82	4.07	5.33	7.87	10.42

TABLE 6

Discharge Table for 90° Triangular Notch

Computed from the formula $Q=2.49\ H^{2.48}$

Head in feet	Head in inches	Discharge in second-feet (Q)	Head in feet	Head in inches	Discharge in second-feet (Q)	Head in feet	Head in inches	Discharge in second-feet (Q)
0.20	2 3/8	0.046	0.55	6 5/8	0.564	0.90	10 13/16	1.92
.21	2 1/2	.052	.56	6 3/4	.590	.91	10 15/16	1.97
.22	2 5/8	.058	.57	6 13/16	.617	.92	11 1/16	2.02
.23	2 3/4	.065	.58	6 15/16	.644	.93	11 3/16	2.08
.24	2 7/8	.072	.59	7 1/16	.672	.94	11 1/4	2.13
.25	3	.080	.60	7 3/16	.700	.95	11 3/8	2.19
.26	3 1/8	.088	.61	7 5/16	.730	.96	11 1/2	2.25
.27	3 1/4	.096	.62	7 7/16	.760	.97	11 5/8	2.31
.28	3 3/8	.106	.63	7 9/16	.790	.98	11 3/4	2.37
.29	3 1/2	.115	.64	7 11/16	.822	.99	11 7/8	2.43
.30	3 5/8	.125	.65	7 13/16	.854	1.00	12	2.49
.31	3 3/4	.136	.66	7 15/16	.887	1.01	12 1/8	2.55
.32	3 13/16	.147	.67	8 1/16	.921	1.02	12 1/4	2.61
.33	3 15/16	.159	.68	8 3/16	.955	1.03	12 3/8	2.68
.34	4 1/16	.171	.69	8 1/4	.991	1.04	12 1/2	2.74
.35	4 3/16	.184	.70	8 3/8	1.03	1.05	12 5/8	2.81
.36	4 5/16	.197	.71	8 1/2	1.06	1.06	12 3/4	2.87
.37	4 7/16	.211	.72	8 5/8	1.10	1.07	12 13/16	2.94
.38	4 9/16	.226	.73	8 3/4	1.14	1.08	12 15/16	3.01
.39	4 11/16	.240	.74	8 7/8	1.18	1.09	13 1/16	3.08
.40	4 13/16	.256	.75	9	1.22	1.10	13 3/16	3.15
.41	4 15/16	.272	.76	9 1/8	1.26	1.11	13 5/16	3.22
.42	5 1/16	.289	.77	9 1/4	1.30	1.12	13 7/16	3.30
.43	5 3/16	.306	.78	9 3/8	1.34	1.13	13 9/16	3.37
.44	5 1/4	.324	.79	9 1/2	1.39	1.14	13 11/16	3.44
.45	5 3/8	.343	.80	9 5/8	1.43	1.15	13 13/16	3.52
.46	5 1/2	.362	.81	9 3/4	1.48	1.16	13 15/16	3.59
.47	5 5/8	.382	.82	9 13/16	1.52	1.17	14 1/16	3.67
.48	5 3/4	.403	.83	9 15/16	1.57	1.18	14 3/16	3.75
.49	5 7/8	.424	.84	10 1/16	1.61	1.19	14 1/4	3.83
.50	6	.445	.85	10 3/16	1.66	1.20	14 3/8	3.91
.51	6 1/8	.468	.86	10 5/16	1.71	1.21	14 1/2	3.99
.52	6 1/4	.491	.87	10 7/16	1.76	1.22	14 5/8	4.07
.53	6 3/8	.515	.88	10 9/16	1.81	1.23	14 3/4	4.16
.54	6 1/2	.539	.89	10 11/16	1.86	1.24	14 7/8	4.24
						1.25	15	4.33

TABLE OF HYDRAULIC EQUIVALENTS

1 cubic foot of water weighs $62\frac{1}{2}$ pounds.
1 cubic foot equals approximately $7\frac{1}{2}$ gallons.
1 cubic foot per second equal 450 gallons per minute, approximately.
1 cubic foot per second flowing 1 hour equals 1 acre inch.
1 cubic foot per second flowing 12 hours equals 1 acre foot.
1 cubic foot per second flowing 24 hours equals 2 acre feet.
1 acre foot equals 43,560 cubic feet.
1 acre inch equals 113 tons or 226,850 pounds of water.

Miner's inch: In Nevada, Arizona, Montana, Oregon and central California one miner's inch equals $\frac{1}{40}$ of a second foot. In southern California, Idaho, Kansas, New Mexico, North Dakota, South Dakota, Nebraska and Utah one miner's inch equals $\frac{1}{50}$ of a second foot. In Colorado 1 miner's inch is $\frac{1}{38.4}$ of a second foot.

DUTY OF WATER

Duty of water may be expressed in various ways. Very often the total depth of water required to bring a crop to maturity is stated as so many acre feet or acre inches of water, and called the duty of water for this particular crop. This figure for any crop naturally varies considerably with different soils and climatic conditions, and also with different seasons. The quantity and distribution of the rainfall is a vital factor in the duty of water, governing the amount of water that must be supplied by irrigation. The importance of knowing the total quantity of water that must be lifted by pumping to mature a crop is discussed under cost of pumping.

Another expression of the duty of water is the number of acres of land that can be irrigated during a season by a given flow of water, usually one second foot. Ordinarily this expression of the duty of water is for the entire irrigating season, and not necessarily for any particular crop; but when water is pumped and the quantity available is limited, the number of acres that can be covered within a given time during the period of greatest need becomes a limiting factor. Calculations of the number of acres that can be irrigated by a given stream can be readily made if the size of the stream, the depth of water required for each irrigation and the rotation period or time between irrigations are known.

Let it be assumed, for example, that for a certain crop on a particular soil six inches of water per irrigation are required and during the hottest weather one irrigation every 10 days is necessary. Then if one second foot, giving 24 acre inches every 24 hours, is available, four acres can be irrigated each day. At this rate 40 acres can be irrigated in the 10 day period.

If it be assumed that for the above crop three inches per irrigation is sufficient, then in the 10 day period a total of 80 acres can be irrigated. Likewise the length of time between irrigations may be more or less than the assumed period of 10 days, with a consequent variation in the amount of land that can be covered within the rotation.

From this brief discussion it can be seen that the duty of water or number of acres that can be served by a given stream of water depends

upon a number of variable factors and cannot be stated in exact figures, but must be determined for any stated locality and crop by a study of all the factors involved.

COST OF PUMPING

Under any system of farming where water must be lifted, the cost of pumping becomes a vital factor in the economic production of crops. The upper limit of this cost can scarcely be expressed in definite figures because the cost of pumping is only one of the factors affecting farming profits in any locality. Pumping costs should rather be considered in connection with the net returns per acre. The soil,

The Lindsay Well, Las Vegas, Nevada. Many artesian well areas begin with flowing wells and end with pumping. The excellent well shown in this picture gives visual evidence of a considerable water supply.

its fertility and adaptability to particular crops, the climate which governs the class of crops that can be grown, the distance from market and the means of transportation which govern the cost of marketing, are all factors influencing the returns per acre. In general it may be stated that the higher the net returns per acre the higher will be the various items of expense in growing the crop, and the higher will be the permissible cost of pumping. In other words, with a crop that gives a very high return per acre the cost of pumping may be quite high without greatly affecting the net return; whereas, with a crop that gives a very low return per acre, the margin between the return and the cost of production does not permit of a very large expenditure

for pumping. To illustrate further: Consider the condition of some of the interior valleys in Nevada. The climate is such that only the rather hardy, short season crops can be grown, and the distance from market is so great that only those crops that can be consumed on the farm are profitable. Under such conditions the returns per acre from farming are necessarily small and if pumping is practiced the cost per acre for lifting the water must be very low. This means that the first cost of the wells must be moderate and that the distance through which the water is lifted must be small.

On the other hand, the extreme southern end of Nevada has a mild climate with a very long growing season. The distance from markets is considerable, but means of transportation are available. These conditions permit the growing of a rather wide range of crops and the selection of those crops that give large returns per acre, and this in turn permits a higher water cost.

The quantity of water that must be applied to a crop to bring it to maturity is likewise a variable factor, depending on the crops grown, the soil, and the climate.

Until all the factors that enter into the cost of production and the possible returns per acre are known it is impossible to state a figure expressing the highest cost of pumping or the maximum lift that will allow a profitable return per acre on the crop grown.

If the cost of all the different items entering into the cost of lifting water were uniform or nearly so, it would be possible to establish the cost per acre foot of water per foot of lift, and by applying this figure to any set of conditions one could estimate the cost of lifting any amount of water through any given distance. Then, with a knowledge of the probable net returns from any crop in a community it would be a simple problem to determine the limit of economical pumping. Suppose that in a certain community a crop requiring three acre feet of water is to be grown, the crop returns being such that after deducting fixed charges and production costs a sum of $6 would remain for pumping costs. The problem is then to determine the maximum pumping lift. If it is assumed that the rate for lifting water had previously been found to be 5 cents per acre foot per foot of lift, then the cost of lifting three acre feet one foot would be 15 cents, and the maximum allowable lift would be $6 divided by 15 cents or 40; that is, the greatest depth from which water could be pumped would be 40 feet. Similarly a crop requiring two acre feet of water and returning a net profit of such amount that $20 per acre remained to pay for pumping could be profitably grown with water lifted a total of 200 feet, provided the basic rate of 5 cents was still correct.

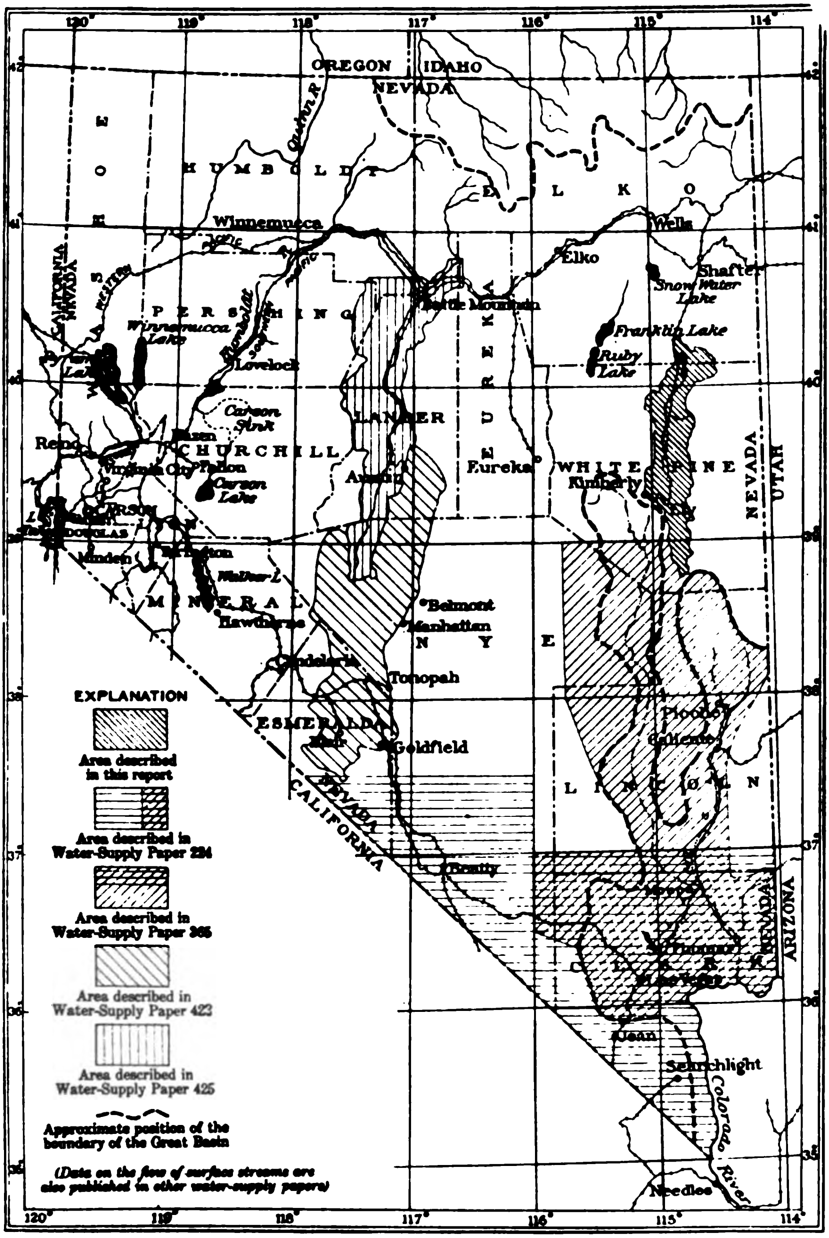
However, the items of cost vary considerably. The price of fuel fluctuates rather widely, and the cost of transporting the fuel from the railroad to the farm increases rapidly with the distance hauled. If electric power is available the first cost of an extension from the power line to the pumping plant must be considered and the interest and depreciation added to the power costs. The first costs of wells and pumping equipment range over wide limits. It costs more per acre-inch to lift water with pumps of small capacities than it does with pumps of larger capacities. Also the rate of cost of pumping increases

appreciably as the total lift increases. That is, if the rate is 5 cents per acre foot per foot lift with a total head of 40 feet the rate may be as much as 7½ cents when the head is increased to 100 feet.

With so many variable factors entering into the cost of lifting water, it is impossible to establish a general basic rate for pumping costs. Hence it is difficult to forecast the pumping cost or to determine the maximum pumping limit for any locality without exact data on the cost of all the various factors entering into the problem. In the absence of more exact information the following rates may be used in making rough estimates of pumping costs and allowable lifts for average conditions in Nevada:

TABLE 7

Pumping lift feet	*Rate (Cost of lifting one acre foot one foot)*	*Cost of lifting one acre foot maximum lift for rate*
10– 20	$0.06	$1.20
20– 40	.08	3.20
40–100	.10	10.00



MAP OF NEVADA SHOWING AREAS COVERED BY THE PRESENT AND OTHER WATER-SUPPLY PAPERS OF THE UNITED STATES GEOLOGICAL SURVEY

25 0 25 50 75 100 MILES

1920

Map Reproduced from Water Supply Paper No. 476 U. S. Geological Survey, Showing Areas in Nevada Described in Various Water Supply Papers. (See list of references at end of this Bulletin.)

REFERENCES

Farmers Bulletin No. 813, Construction and Use of Farm Weirs.
Farmers Bulletin No. 1904, Pumping from Wells for Irrigation.
The following Water Supply Papers of the U. S. Geological Survey:

Water Supply Paper No. 224, Some Desert Watering Places in Southeastern California and Southwestern Nevada, by Walter C. Mendenhall.

Water Supply Paper No. 365, Ground Water in Southeastern Nevada, by Everett Carpenter.

Water Supply Paper No. 423, Geology and Water Resources of Big Smoky, Clayton, and Alkali Spring Valleys, Nevada, by Oscar E. Meinzer.

Water Supply Paper No. 425D, Ground Water in Reese River Basin and Adjacent Parts of the Humboldt River Basin, Nevada, by Gerald A. Waring.

Water Supply Paper No. 540C, Ground Water in Pahrump, Mesquite, and Ivanpah Valleys, Nevada and California, by C. A. Waring.

Water Supply Paper No. 467, Exploratory Drilling for Water and Use of Ground Water for Irrigation in Steptoe Valley, Nevada, by W. O. Clark and C. W. Riddell, with an Introduction by O. E. Meinzer.

United States Department of Agriculture, Bureau of Soils, Soil Survey of the Las Vegas Area, Nevada, by E. J. Carpenter and F. O. Youngs.

For information concerning duty of water for various crops refer to Bulletin 96 of the Nevada Agricultural Experiment Station, Irrigation of Field Crops in Nevada, by C. S. Knight and George Hardman. Also, various bulletins of the Department of Agriculture and of the State Experiment Stations.

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
1928

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 113 RENO, NEVADA July, 1928

RED WATER DISEASE OF CATTLE

(*Bacillary hemoglobinuria*)

By

Dr. EDWARD RECORDS

Assisted by

Dr. L. R. VAWTER

Of the Department of Veterinary Science

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

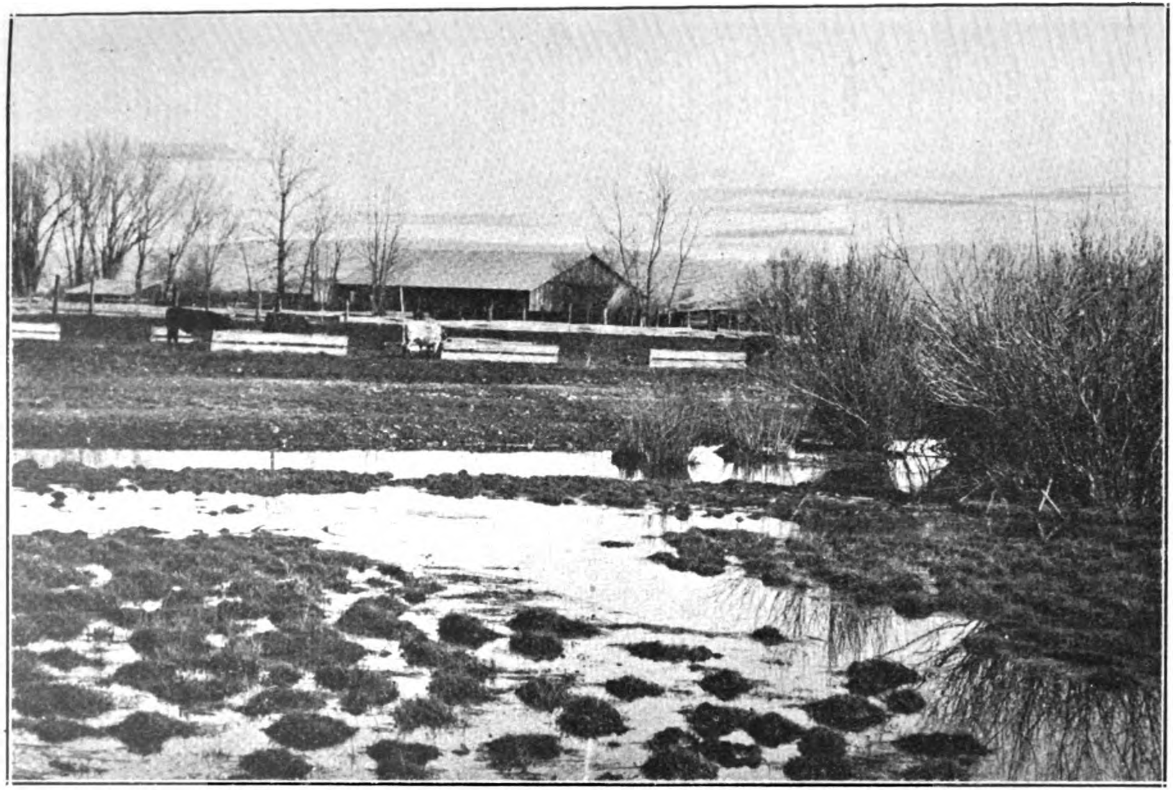
Printed at the
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[04]

NEVADA AGRICULTURAL EXPERIMENT STATION

STAFF

SAMUEL B. DOTEN, M.A., Director........Entomology
CHARLES E. FLEMING, B.S.A........Range Management
EDWARD RECORDS, V.M.D........Veterinary Science
GEORGE HARDMAN, M.S........Irrigation
M. R. MILLER, M.S........Chemistry
LYMAN R. VAWTER, D.V.M........Assistant in Veterinary Science
F. L. BIXBY, C.E........Collaborator in Irrigation Engineering
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)
ROBERT STEWART, Ph.D........Soils Research
V. E. SPENCER, M.S........Associate, Soils Research
CHESTER BRENNEN, B.A........Economist in Range Management
F. B. HEADLEY........Farm Development
R. M. CLAWSON, B.S........Assistant in Farm Development
LEWIS KEHOE, B.S........Fellow in Chemistry
ANDREW YOUNG........Assistant in Range Management
MATILDA MARSHALL........Specialist in Farm Cost Studies
LOUISE LEWERS........Secretary to Veterinary Science
MARTHA R. BRUCE........Illustrator, and Secretary to Director
GRACE COSTELLO........Librarian and Secretary



A Condition Highly Favorable to the Occurrence of the Red Water Disease.

RED WATER DISEASE OF CATTLE

(*Bacillary hemoglobinuria*)

INTRODUCTION

The "red water disease" of cattle, a local name for *bacillary hemoglobinuria*, is more or less prevalent throughout Nevada. Accurate information on the early history of the disease in Nevada is somewhat difficult to obtain, because in earlier years its true nature was not recognized and it was confused with anthrax and other diseases which it more or less resembles. Information collected from long resident ranchers and old newspaper files seems to demonstrate quite conclusively, however, that material losses from the disease occurred at least forty years ago. Since 1914 an active and comprehensive study of the disease has been under way at the Nevada Agricultural Experiment Station.

This work has resulted in the discovery of the microorganism or germ causing the disease. A satisfactory curative serum has been produced, and what promises to be a reliable vaccine for its prevention. The results of this work, which was of a highly technical nature, have been published from time to time in scientific journals; but the details are naturally not of great interest to the layman.

The purpose of this bulletin is to render available to stockmen and ranchers a brief and understandable description of the disease, together with an account of the available means of preventing losses from it. There will also be published shortly another technical bulletin describing in detail the work done at this Station. Those interested in the more scientific phases of this problem should consult this latter bulletin and the previously published papers referred to above.

OCCURRENCE OF THE DISEASE

In addition to Nevada, this disease is now known to occur in certain areas of California, Oregon, and Washington, and in Chile, South America. Further observations will probably demonstrate a still wider distribution. It is noteworthy, however, that wherever this disease has been proved to exist, it occurs under similar local conditions.

Red water disease of cattle is primarily a lowland disease, regardless of the actual altitude at which it occurs. Practically all material losses occur on pasture areas such as natural meadows, or irrigated lands where drainage is poor, and there is at least a periodic excess of water that does not drain away promptly and becomes dormant or stagnant. Drainage water from such areas also appears capable of infecting cattle

when drunk by them under certain conditions. Cases rarely, if ever, occur on dry upland areas or on the open range where cattle do not have access to poorly drained lands such as those described. Occasional losses occur on dry hay in feed lots, but these are usually traceable to hay cut from dangerous meadows or to drinking water draining from such areas.

Red water is primarily a disease of cattle, at least in Nevada. Occasional losses of sheep have come to our attention but they appear to be rare. Whether this is due to the fact that Nevada sheep are rarely pastured on areas where the disease is prevalent, or to the fact that they are more resistant, is not known definitely at this time; we are inclined to believe the former.

ECONOMIC IMPORTANCE

Taking one year with another, the aggregate losses from red water disease in Nevada have been a fairly serious drain on the livestock industry, and one well worth preventing with the means now at our disposal. The losses from the disease vary greatly from year to year on individual ranches and in different locations. A number of factors affect this result, such as water conditions, average temperature, and the susceptibility of the cattle on pastures.

Severe sudden outbreaks of this disease where a large number of cases occur in groups of cattle simultaneously or within a short time are infrequent; but they do occur. When a large number of cattle which have never been exposed to the disease and are therefore highly susceptible are moved in on a dangerous area, cases are apt to develop rapidly. The same thing may occur when premises previously free from the disease are flooded with water drained from a dangerous area. The usual thing, however, is the appearance of occasional cases in the herd throughout the season when the disease is most prevalent. Generally speaking, red water is a disease of summer and fall, most of the losses occurring between July first and December first. Water and temperature conditions appear to be the controlling factors in the prevalence of the disease. Occasional cases occur throughout the year in the involved districts.

DIAGNOSIS

To veterinarians and stockmen who have had any considerable experience with the disease the diagnosis is usually fairly easy, even very early in the attack. The disease most apt to be confused with red water is anthrax, which unfortunately is also found in many of the Nevada districts where red water disease occurs. The situation is further complicated by the fact that anthrax is also most apt to appear under conditions of season, water, and temperature favorable to the occurrence

of red water disease. Fortunately graduate veterinarians thoroughly familiar with red water disease are available in Nevada in practically all districts where the disease occurs. Stockmen should by all means secure their services for the diagnosis of suspicious cases either during life or after death, and for treatment of early cases and for outlining plans to control the disease.

The symptoms shown by an animal afflicted with red water disease are fairly constant and uniform from the time the disease first becomes apparent to the death of the animal. Appetite and cud chewing, bowel movements and milk flow in milking cows suddenly cease. The animal is apt to stand apart from the herd. It does not want to move and usually grunts with each step taken. The hair is dry, dull and raised. The eyes have a peculiar sunken appearance quite characteristic of the disease and are usually bloodshot or yellow. Breathing is rather rapid but shallow, the animal may grunt slightly each time the breath is expelled. The nose is dry and hot. The temperature is high, reaching 106 early in the disease, but it falls rapidly and is usually subnormal some time before death. The pulse is increased in rate but weak, with marked visible pulsations in the veins of the neck.

As the disease progresses, bowel movements become very frequent, and small in amount. Later they usually contain much blood. Urine is passed frequently and generally in fair amounts. Starting with a faint pinkish tinge, the color of the urine changes until, late in the disease, it is a deep garnet or port wine color. This coloration of the urine, due to dissolved blood pigment, is the most striking symptom of the disease and the one from which it gets its common name, "red water." In this connection it should be borne in mind, however, that blood-tinged urine may also occur in anthrax.

The duration of the disease after it becomes noticeable varies from a few hours to several days, averaging about thirty-six hours. The death rate is very high, in most localities reaching practically 100% of all untreated cases definitely diagnosed.

The changes found in an animal's body after death from red water disease are very striking; and some of them are quite typical of this disease. These changes will not be dealt with here in detail, however, as the danger of confusion with anthrax which is readily contracted by man makes it inadvisable for any one except a trained veterinarian to examine the carcass of an animal suspected of having died of red water disease. The general picture on opening a red water carcass is one of hemorrhage. Both chest and abdominal cavities contain bloody fluid. The membranes that line both cavities and cover the intestines show more or less extensive deposits of blood beneath their surfaces. The lungs are yellowish-red instead of bright pink as in health. The

spleen is dark and discolored but not much enlarged. The kidneys are speckled with blood spots; and any urine left in the bladder is dark red in color.

The most striking change and the one found uniformly and, so far as we know, only in this disease, is in the liver. The liver invariably contains a firm, rather brittle, dirty yellowish-grey area, well defined from the normal portion and slightly raised above the surface. This area may vary from a few inches in diameter up to a size about one-fifth of the whole liver. This liver area is thought to be the point where the germs causing this disease first establish themselves in the animal's body and set up the processes that later result in death.

TREATMENT

Long experience with the medicinal or drug treatment of red water disease has shown that it is of little value. It is very doubtful whether even the most skillful treatment with drugs alone materially influences the death rate.

Following the discovery in 1923 of the germ causing red water disease and its isolation in what is known as a pure culture, a curative serum was prepared at the Nevada Agricultural Experiment Station. The results obtained from the use of this serum have been most gratifying. Taking all classes of cases, early and advanced, but all well enough developed for positive diagnosis, the recoveries under serum treatment have averaged about seventy-five per cent, while the death rate among animals not treated is practically one hundred per cent.

Several factors influence the chances for recovery of the individual animal under serum treatment. The serum should, of course, be given as early as possible in the course of the disease. Cows well along with calf are a very bad risk, and the death rate is high even when serum is given early in the attack. In herds where red water cases are of frequent occurrence, it is often advisable as an economic preventive measure to administer serum to animals considered suspicious even before absolutely definite symptoms develop. This will tend to check the development of the disease and, even if the animal was not actually affected with red water disease, the serum administered will do no harm. For curative purposes the serum is injected directly into the animal's veins.

Caution must be exercised with range cattle or others unaccustomed to handling when they are found, or suspected, to be suffering with this disease. Undue excitement or exertion incident to roping or driving into chutes for treatment may seriously weaken the animal or actually cause death before treatment.

Suitable medicinal treatment in the way of stimulants, etc., tends to hasten recovery and to leave the animal in better shape after the attack, and may be used to advantage in connection with the serum. Animals sick with red water disease may be allowed water to drink during the attack but should have no solid food until well on the way to recovery. During the course of the disease, and for a reasonable time afterward, exercise and excitement should be avoided. Bulls should not be used for service for at least three to four weeks after apparent recovery. Purgatives or physics should never be given to animals suspected of having red water disease, as they increase the severity of the attack and lessen the chance of recovery.

In all cases where red water disease is suspected a veterinarian should be called promptly so that serum treatment and other appropriate measures may be employed as early in the attack as possible.

As anti red water serum has now passed the experimental stage, it is no longer produced and distributed free by the Nevada Agricultural Experiment Station. An ample supply of reliable serum from commercial laboratories is now available, and veterinarians practicing in red water districts generally have a supply on hand. The present price of anti red water serum is about six dollars per dose which makes its use well worth while on dairy cattle or other cattle of fair value. If given reasonably early in the attack, one dose is usually sufficient, but in some cases a second dose can be given to advantage.

PREVENTION

In red water, as in the case of all other infectious and contagious diseases, prevention should be the object sought rather than the treatment of cases after they occur. While there is still much to be learned as to the control of red water disease, even with our present knowledge, losses may be materially checked and in some cases probably entirely prevented.

If the use of pastures on which red water disease is known to occur is unavoidable, much can often be done to make them less dangerous. Excess water, and particularly standing water, should be eliminated. Where heavy or uneven irrigation cannot be avoided, the cattle should be removed until after the excess water has subsided. Sump holes and low spots should be drained or fenced off wherever possible, and a supply of pure flowing water should be made available for drinking. Feed lot losses on dry hay appear to be almost always due to contaminated drinking water. These losses can usually be prevented by limiting the cattle to pure spring or well water for drinking purposes.

When for economic reasons, or otherwise, it is impracticable to render

pastures relatively safe, other methods of preventing losses must be used. When cases start to occur rapidly among a susceptible lot of cattle, the administration of a small or immunizing dose of serum is often effectual. The serum used for this purpose is the one already referred to under treatment, but the dose used is relatively so small that the cost is only about one dollar per head. While the results from serum used in this way, if successful at all, are almost immediate, the protection against the disease is short-lived, probably not exceeding six weeks at the most.

Our present knowledge of this disease indicates that in areas where it is known to occur vaccination affords the most economical and effective means of prevention. So far, vaccination has been tried out on several thousand head of cattle under natural field conditions, and no noticeably bad effects from the vaccine have been noted, even among cattle kept under very close observation. Practically no cases of red water have occurred among the vaccinated cattle, while a considerable number of cases have occurred among the unvaccinated animals kept with them for comparison under the same conditions.

It is not known definitely just how long vaccination will protect the treated animals, but apparently the vaccine now available will prevent serious losses for at least six months. It is hoped that later improvements in the vaccine used will prolong this period of protection to at least one year.

As protection or immunity following vaccination is not established immediately, cattle should be vaccinated at least two weeks before the usual red water season or before they are moved onto dangerous areas. This is particularly important as there is probably a short period of a few days immediately after vaccination when they are even more susceptible to the disease than unvaccinated cattle. Vaccination has the further advantage of being inexpensive, the material costing only ten to fifteen cents per dose.

CONCLUSION

The accurate diagnosis and control of red water disease in different localities, and under varying conditions at different periods of the year, presents many problems which cannot be dealt with in detail in a bulletin of this sort. Further study of the disease and added experience will also undoubtedly develop better methods of control.

In order to meet this condition and to furnish the latest available information, the staff of the Department of Veterinary Science, University of Nevada, will be glad to cooperate with any livestock owner or veterinarian interested in this problem.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 114 RENO, NEVADA July, 1928

HOG FEEDING EXPERIMENTS

In this bulletin are reported the results of hog feeding experiments conducted by the Nevada Agricultural Experiment Station in cooperation with the Office of Western Irrigation Agriculture of the U. S. Department of Agriculture. The experiments were conducted on the Newlands Experiment Farm near Fallon, Nevada.

By
F. B. HEADLEY
Chief, Department of Farm Development

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[63]

NEVADA AGRICULTURAL EXPERIMENT STATION

STAFF

Samuel B. Doten, M.A., Director..........Entomology
Charles E. Fleming, B.S.A..........Range Management
Edward Records, V.M.D..........Veterinary Science
George Hardman, M.S..........Irrigation
M. R. Miller, M.S..........Chemistry
Lyman R. Vawter, D.V.M..........Assistant in Veterinary Science
F. L. Bixby, C.E..........Collaborator in Irrigation Engineering
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)
Robert Stewart, Ph.D..........Soils Research
V. E. Spencer, M.S..........Associate, Soils Research
Chester Brennen, B.A..........Economist in Range Management
F. B. Headley..........Farm Development
R. M. Clawson, B.S..........Assistant in Farm Development
Lewis Kehoe, B.S..........Fellow in Chemistry
Andrew Young..........Assistant in Range Management
Matilda Marshall..........Specialist in Farm Cost Studies
Louise Lewers..........Secretary to Veterinary Science
Martha R. Bruce..........Illustrator, and Secretary to Director
Grace Costello..........Librarian and Secretary

SUMMARY

A number of experiments have been conducted for the purpose of determining the value of milk in the ration, and of finding the most economical rations to use under various price combinations.

Rations were fed without milk and with medium and heavy milk rations in addition to the grain. The money value per hundredweight of milk in the ration was found to be variable, and depends on the status of other factors; viz. (1) the price receivable for the hogs, (2) the price of grain, (3) the per cent of milk in the ration, (4) the per cent of grain in the ration, and (5) whether the pigs are on pasture or in dry lot. The value of the milk per hundredweight varies according to the conditions under which it is fed. Each gallon of milk is more effective when fed in a limited milk ration than when the pigs are given approximately all they can drink. Each gallon of milk is also more effective in producing gains when the pigs are receiving a light grain ration than when they are being full fed on grain. Milk was found to be more essential to the growth of pigs in dry lot than on pasture.

It costs more to produce gains on hogs in winter than in summer, and in dry lot than on pasture.

Profitable gains can be made under certain price conditions. When the ratio of price of grain to the price of gain is as 1: 6, or, stated in another way, when one pound of hog will buy six pounds of grain, hog raising will always be profitable if the more economical rations shown herein are used. When the hog-grain ratio is reduced to 1: 5 greater care must be used is selecting the ration in order to obtain profitable returns.

A method has been devised to show by means of calculating charts the cost of production per pound of gain with varying prices of feeds and labor. This makes it possible to calculate in advance the probable net returns that can be obtained from the rations used in these experiments and thus to select the ration best adapted to the price combinations in effect when the feeding of any lot of hogs is begun.

PART I

HOG FEEDING EXPERIMENTS

INTRODUCTION

The number of hogs in Nevada in 1926 as given by the United States Department of Agriculture was estimated at 26,000. The census of 1920 shows that there were on hand at that time 26,645 head. This indicates that hog raising is not considered profitable by the majority of Nevada farmers, and for this reason it has not developed into an important agricultural industry.

There is a general impression among the farmers that hogs cannot be profitably produced even in connection with dairying. This opinion was formed in the prewar days when the price of hogs was usually under 8 cents per pound, and it has apparently not been altered by the higher prices now available. That there are two sides to the question is indicated by the fact that there is a sprinkling of farmers who always keep hogs, and who believe they are obtaining profits from them.

The situation certainly justifies careful experimentation for a number of years to find out under what conditions hog growing is profitable and what factors tend to make it unprofitable. An excellent opportunity to conduct such experiments became available when the dairy experiment was started by this Department in cooperation with the Newlands Experiment Farm operated by the U. S. Department of Agriculture at Fallon. Skim milk was available from the dairy herd, and the experiment farm volunteered to furnish the necessary land for the pens and alfalfa pasture.

Experiments were therefore planned to determine the most efficient and economical rations to use. The feeds utilized have been alfalfa hay, alfalfa pasture, skim milk, ground barley, and ground rye in various combinations. These experiments are supplemental to the dairy experiments and were planned so as to obtain information in regard to the value of skim milk as a supplement to alfalfa and grain, and to indicate under what diverse conditions hog feeding may be profitable.

METHOD OF FEEDING

The method followed for calculating the amount of grain and milk to be fed in these experiments will require some explanation since very few farmers are acquainted with the percentage method of calculating the ration requirements upon the weight of the hogs. When a 2% grain ration is reported it means that 2 pounds of grain is fed for every 100 pounds of hogs in the group. When a 5% milk ration is fed it means that 5 pounds of milk is fed daily for each 100 pounds of live weight. To illustrate, if a group of hogs weighing 1,200 pounds are receiving 2% grain and 5% milk ration, they will be given 24 pounds of grain and 60 pounds of milk daily.

For our experimental purposes the pigs have been weighed and the rations corrected each week, but for practical feeding on the farm it would only be necessary to make an estimate of the total weight of the hogs twice each month, and then feed according to the revised weights.

EFFICIENCY OF THE PERCENTAGE METHOD

No experiments have as yet been conducted to determine if the percentage method used in our experiments is the most economical one to use when limited rations are fed. Various percentage rates have been compared with the pigs full fed or on self-feeders, but when the ration is limited it may be found eventually that there is some more economical method of feeding than that of using a straight percentage rate during the growing period. However, the results of these experiments show that the pounds of grain required per pound of gain is lower than that required from many other feeding tests of other stations. It may be inferred from this that it is economical to base the daily grain ration upon the weight of the hogs. Until some better method is found hog growers might do well to test out the percentage method in a practical way on their own farms.

ESSENTIALS OF PROFITABLE HOG GROWING

The results of these experiments show that under certain methods of feeding and price combinations the raising of hogs may be a profitable enterprise, but there are several factors that affect the net returns regardless of the ration used. The gains that pigs will make on certain feeds can be estimated very closely in advance from the results of these experiments, providing the pigs are kept in good physical condition and free from lice and worms.

LICE AND WORMS

Economical gains cannot be made unless the pigs are kept free from pests and disease. When lice and worms are present the cost of production of gains is greatly increased. It is an essential part of the business of hog raising to keep pigs free from these pests. Lice can be easily controlled by spraying with an oil emulsion, and worms can be most effectually prevented by sanitary measures. Pens that are used repeatedly for farrowing and raising pigs are always sources of worm infection unless thoroughly cleaned and disinfected, which is a difficult task. It is therefore much better to move the sows to new locations before they farrow. It has been found that stronger litters are the result and that the pigs make more rapid gains. The growing pigs are most healthy when they can run on new pasture without access to old pens where pigs have been previously kept. If pigs are to be raised in confinement it is advisable, when possible, to move the pens to new locations.

GRAIN-HOG RATIO

When pigs have been raised with the best of care and the most economical feeding methods used the profits to be obtained are still dependent upon the ratio of the price of grain to the price of hogs. The kind of ration to use will depend to some extent upon the relative prices of grain and hogs. When 100 pounds of hogs are worth 400 pounds of grain the ration that will give the greatest net returns will be quite different from the ration that should be selected when 100 pounds of pork is worth 600 pounds of grain. In other words, the hog and grain outlook for the year should be taken into consideration when the method of feeding is to be selected for the pigs dropped in spring or fall.

REPLACING BARLEY WITH MILK IN RATION

Plan of Experiment.

The first experiment was begun in November, 1925, with only 6 pigs. They were divided into two groups, one of which received 10% milk and 2% barley, while the other received 20% milk and 1% barley. The two groups were kept in separate pens and each had access to alfalfa hay in racks at all times. The hay fed was not weighed in this experiment. The experiment was continued for 96 days.

Results.

The pigs in Group I made the more rapid gains, the average being .83 pound daily, while Group II gained .67 pound daily. Each pig in Group I ate 70 pounds more of barley than those of Group II, but this additional cost was more than repaid by greater gains, so that a larger profit was actually made from Group I than from Group II, even when no charge is made for the milk. The results are reported in detail in Table I:

TABLE I—EFFECTS OF PARTLY REPLACING GRAIN WITH MILK
Amounts Indicate Average Per Pig
(November 12, 1925—February 15, 1926)

	Ration Fed 10% Milk 2% Barley	Ration Fed 20% Milk 1% Barley
Group number	I	II
Number of days	96	96
Initial weight (lbs.)	30	32
Final weight (lbs.)	110	97
Gain in weight (lbs.)	80	65
Daily gain (lbs.)	.83	.68
Daily gain (per cent)	1.22	1.06
Barley fed (lbs.)	129	58
Grain per pound gain (lbs.)	1.62	.89
Milk fed (lbs.)	633	1120
Milk per pound gain (lbs.)	7.9	17.2
Value of wt. increase @ 10c	$8.00	$6.50
Value of grain @ 2c	2.58	1.16
Value of gains over grain cost	5.42	5.34

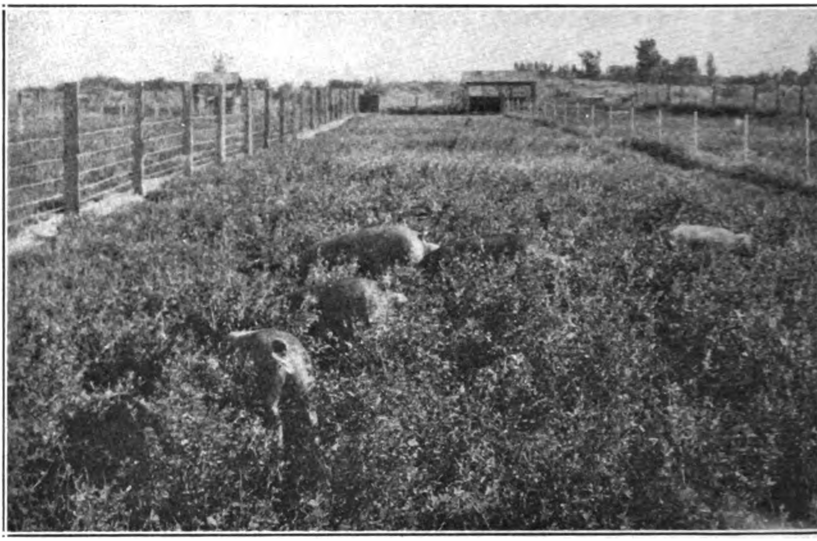
Conclusions.

The net gain in weight of those receiving the heavy milk ration was not so great as the gain of those receiving the 2% barley ration, which indicates that under the conditions of this experiment 10 pounds of milk was not equal in feeding value to one pound of barley. With hogs selling at 10 cents per pound the net return per pig was greater for those receiving the larger grain ration even when no charge is made for milk, but when the price receivable for hogs is only 8 cents the higher milk ration would prove to be the more profitable.

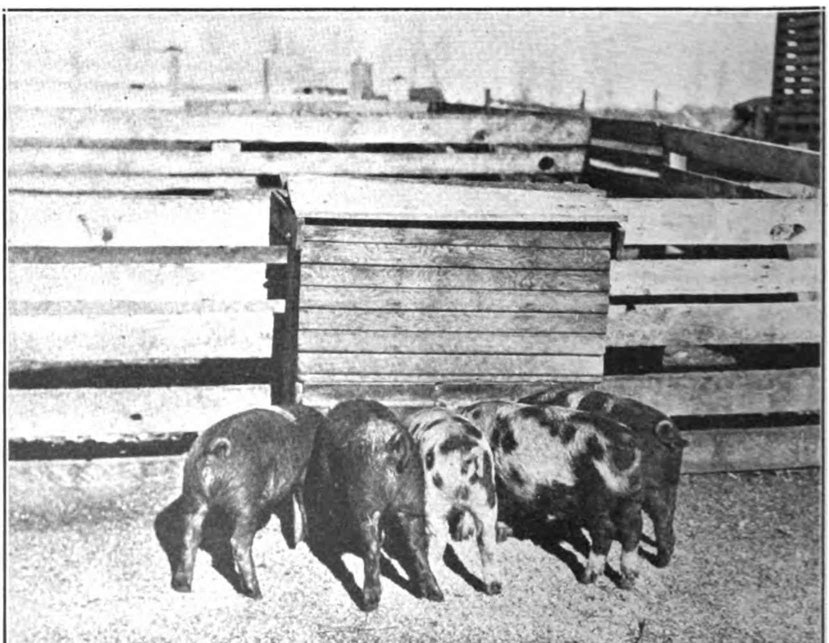
HAND FEEDING V. SELF-FEEDER

Plan of Experiment.

Following this experiment the two groups were redivided into two groups of practically equal weight and were put on a fattening ration



Pigs on Alfalfa Pasture. Each summer three groups of pigs are placed on alfalfa pasture where they receive different milk or grain rations for comparison of economy of gains. Other groups are raised in dry lots where they receive rations identical with those on pasture except that they get alfalfa hay instead of pasture.



Pigs on Self-Feeder. When the pigs in the experimental groups reach an average weight of 140 pounds they are placed on self-feeders for finishing. After three weeks on self-feeders they usually attain an average weight of nearly 200 pounds.

to compare the economy of self-feeders with hand feeding of a 3% grain ration. In this experiment ground rye was fed in nearly equal amount with rolled barley. A 10% ration of skim milk was fed to both groups.

Results.

The pigs on the self-feeder made more rapid gains than those fed by hand, but this may have been because the latter were not getting sufficient grain to make the maximum growth. The number of pounds of grain required to make a pound of gain was greater for the hand-fed group. When the increase in weight is credited at 10 cents and the grain charged at 2 cents a pound the pigs on the self-feeder brought the greatest profit, which amounted to $1.54 per pig more than for the hand-fed group. If the labor of feeding is considered, the margin of profit would be still greater for there is a marked saving in labor when the self-feeder is used. See Table II.

TABLE II—SELF-FEEDERS V. HAND-FEEDING

Amounts Given Indicate Average Per Pig

(February 12, 1926—April 12, 1926)

	Ration Fed 10% Milk 3% Grain	Ration Fed 10% Milk Self-feeder
Group number	III	IV
Number of days	56	56
Initial weight (lbs.)	102	105
Final weight (lbs.)	185	216
Gain in weight (lbs.)	83	111
Average daily gain (lbs.)	1.48	1.98
Average daily gain (per cent)	1.07	1.20
Barley fed (lbs.)	122	163
Rye fed (lbs.)	106	128
Total grain fed	228	291
Milk fed (lbs.)	787	870
Milk per pound gain	9.5	7.8
Barley fed per pound gain (lbs.)	1.47	1.47
Rye fed per pound gain (lbs.)	1.28	1.15
Total grain per pound gain (lbs.)	2.75	2.62
Value weight increase @ 10c	$8.30	$11.10
Value of grain @ 2c	4.56	5.82
Profit over grain cost	3.74	5.28

SUMMER FEEDING EXPERIMENTS IN 1926 WITH VARYING RATIONS

Plan of Experiment.

In the spring of 1926, 21 pigs were secured and divided into five groups, which received rations as follows:

Group

V.........5 pigs on alfalfa pasture, no milk, 2% grain.
VI.........5 pigs on alfalfa pasture, 10% milk, 2% grain.
VII.........5 pigs on alfalfa pasture, 20% milk, 1% grain.
VIII.........3 pigs on alfalfa hay, 10% milk, 2% grain.
IX.........3 pigs on alfalfa hay, 20% milk, 1% grain.

Until the pigs of each group had reached an average weight of 100 pounds, they were fed the rations indicated above, after which they

TABLE III—PIGS ON ALFALFA PASTURE WITH VARYING MILK AND GRAIN RATIONS

Amounts Given Are Averages Per Pig

	Growing period			Fattening period			Both periods*		
	No milk 2% Grain	10% Milk 2% Grain	20% Milk 1% Grain	No milk Self-feeder	5% Milk Self feeder	10% Milk Self-feeder	No milk	Medium milk ration	Heavy milk ration
Group number	V	VI	VII	V	VI	VII	V	VI	VII
Experiment begun	June 5	June 5	June 5	Sept. 4	Aug. 21	Aug. 21	June 5	June 5	June 5
Experiment ended	Sept. 4	Aug. 21	Aug. 21	Oct. 23	Oct. 9	Oct. 9	Oct. 23	Oct. 9	Oct. 9
Number of days	91	77	77	49	49	49	140	126	126
Days per cwt. gain	163	118	119	52	56	52	93	82	79
Initial weight (lbs.)	39.6	36.8	40.6	95.4	102.2	105.4	39.6	36.8	40.6
Final weight (lbs.)	95.4	102.2	105.4	190.0	189.8	200.2	190.0	189.8	200.2
Gain in weight (lbs.)	55.8	65.4	64.8	94.6	87.6	94.8	150.4	153.0	159.6
Daily gain (lbs.)	.61	.85	.84	1.92	1.79	1.93	1.07	1.21	1.27
Daily gain (per cent)	.99	1.34	1.25	1.40	1.27	1.32	1.14	1.32	1.28
Grain fed (lbs.)	103	93	48	375	330	330	478	423	378
Grain per pound gain (lbs.)	1.85	1.42	.74	3.97	3.77	3.48	3.18	2.76	2.37
Milk fed (lbs.)	....	465	972	....	337	713	....	802	1685
Milk per pound gain (lbs.)	....	7.1	15.0	....	3.9	7.5	....	5.2	10.6
Value of grain @ 10¢	$5.58	$6.54	$6.48	$9.46	$8.76	$9.48	$15.04	$15.30	$15.96
Value of grain @ 2¢	2.06	1.86	.96	7.50	6.60	6.60	9.56	8.46	7.56
Profit over grain cost	3.52	4.68	5.52	1.96	2.16	2.88	5.48	6.84	8.40

*Year 1926.

TABLE IV—PIGS ON ALFALFA HAY WITH VARYING MILK AND GRAIN RATIONS

Amounts Given Are Averages Per Pig

	Growing period		Fattening period		Both periods*	
	10% Milk 2% Grain	20% Milk 1% Grain	5% Milk Self-feeder	10% Milk Self-feeder	Medium milk ration	Heavy milk ration
Group number	VIII	IX	VIII	IX	VIII	IX
Experiment begun	June 12	June 12	Sept. 4	Sept. 4	June 12	June 12
Experiment ended	Sept. 4	Sept. 4	Oct. 30	Oct. 23	Oct. 30	Oct. 23
Number of days	84	84	56	49	140	133
Days per cwt. gain	113	112	65	51	87	78
Initial weight (lbs.)	29.7	30.3	104.3	105.3	29.7	30.3
Final weight (lbs.)	104.3	105.3	190.7	201.7	190.7	201.7
Gain in weight (lbs.)	74.6	75.0	86.4	96.4	161.0	171.4
Daily gain (lbs.)	.89	.90	1.54	1.97	1.15	1.29
Daily gain (per cent)	1.50	1.50	1.11	1.34	1.34	1.44
Grain fed (lbs.)	90	48	375	313	465	361
Grain per pound gain (lbs.)	1.20	.64	4.34	3.25	2.89	2.11
Milk fed (lbs.)	504	1169	401	723	905	1892
Milk per pound gain (lbs.)	6.8	15.6	4.64	7.5	5.6	11.0
Value of gain @ 10¢	$7.46	$7.50	$8.64	$9.64	$16.10	$17.14
Value of grain @ 2¢	1.80	.96	7.50	6.26	9.30	7.22
Profit over grain cost	5.66	6.54	1.14	3.38	6.80	9.92

*Year 1926.

were all given an unlimited grain ration in self-feeders, but the pasture groups remained in pasture and the hay-fed groups remained in the dry lots throughout both the growing and fattening periods. The amount of milk in the ration during the fattening period was reduced to one-half of that fed during the growing period. The results of the experiment conducted during the summer of 1926 are given in detail in Tables III and IV, pages 12 and 13 of this bulletin.

In the pasture lots there was very little difference between the rate of gain of Groups VI and VII, but where milk is abundant the heavier milk ration would result in the most economical gains. In the two dry-lot groups there was also a slight difference in favor of the heavy milk ration as shown by the rate of gain. This result is the reverse of that obtained in the winter feeding of Groups I and II.

Very satisfactory gains were made by all groups and a saving in grain cost was obtained in all cases where milk was fed. When grain was charged at 2 cents and gains credited at 10 cents per pound the saving resulting from the milk appeared to be greater for the pigs on alfalfa hay than for those on alfalfa pasture. In this particular experiment the pigs in the dry lot made more economical gains than those on pasture, probably for the reason that the pasture was not quite ample for their requirements during a part of the growing season. In order to present the relative values of the various rations in an easily understood form, the profit over grain cost is given. These profits may be easily recalculated for any other cost of grain or value of gain from the data given in Tables III and IV.

TABLE V—PROFIT PER PIG ABOVE FEED AND LABOR COST

Group	Ration	Value of gains @ 10¢	Value of grain fed @ 2¢	Value of milk fed @ 12½¢ cwt.	Value of labor	Total costs[1]	Net profit
V	No milk, alfalfa pasture	$15.04	$9.56	....	$2.80	$12.36	$2.68
VI	Medium milk ration, alfalfa pasture	15.30	8.46	$1.00	2.52	11.98	3.32
VII	Heavy milk ration, alfalfa pasture	15.96	7.56	2.11	2.52	12.19	3.77
VIII	Medium milk ration, alfalfa hay	16.10	9.30	1.13	2.80	13.23	2.87
IX	Heavy milk ration, alfalfa hay	17.14	7.22	2.37	2.66	12.25	4.89

[1]Does not include any charge for pasture or for hay.

Winter v. Summer Feeding.

The rations for Groups I and II were identical with those of Groups VIII and IX, except that the former were fed in winter and the latter in summer. It will be seen from Table VI that more rapid and economical gains were made in summer than in winter, which indicates that cold weather has the effect of slowing up the gains of the growing pigs. This table shows the results for the growing period only. During the fattening period the winter and summer groups were not handled in the same manner so that their relative gains cannot be directly compared.

TABLE VI—COMPARISON OF EFFECTS OF WINTER AND SUMMER ON FEED REQUIREMENTS AND GAINS

	Winter, 1925–1926		Summer, 1926	
	2% Grain 10% Milk	1% Grain 20% Milk	2% Grain 10% Milk	1% Grain 20% Milk
Number of days	96	96	84	84
Gain in weight	80	65	74.6	75
Daily gain (lbs.)	.83	.68	.89	.90
Daily gain (per cent)	1.22	1.06	1.5	1.5
Grain per pound gain	1.62	.89	1.20	.64
Milk per pound gain	7.93	17.2	6.8	15.6

WINTER FEEDING EXPERIMENTS, 1926–1927

Plan of Experiment.

Twelve weanling pigs having an average weight of 30½ pounds were divided into two groups with six pigs in each group. To Group X was fed a 2% barley ration and 5% milk ration, and to Group XI was fed a 1% barley ration and 10% milk ration. They were fed on the growing ration until the average weight was just under 150 pounds, when they were transferred to self-feeders. Instead of the usual alfalfa hay ration for pigs in dry lot, they were given an unlimited supply of alfalfa meal.

Effect of Feeds on Growth.

The pigs receiving the smaller grain ration made up for it in part by eating 63% more alfalfa meal in addition to the extra milk. The additional alfalfa meal and milk was not sufficient to make up for the extra grain received by Group X, and the pigs in Group XI required over two weeks to attain the same weight. This slowing down in the growth of those receiving the smaller grain ration is illustrated in Chart I.

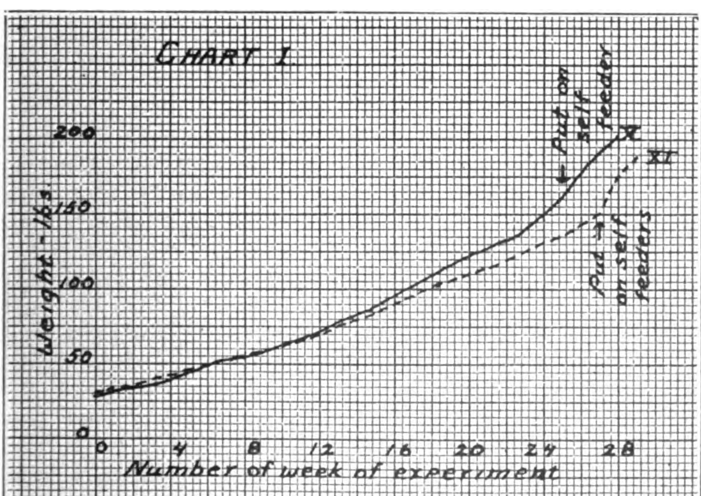


Chart I shows the difference in the rate of growth of two groups of pigs as a result of difference in rations. Group X received 2% grain and 5% milk; Group XI received 1% grain and 10% milk.

For each 100 pounds of gain during the growing period the two groups received:

	Group X	Group XI
Grain (lbs.)	213	127
Milk (lbs.)	536	1268
Alfalfa meal (lbs.)	148	241

The nutrients received by each group per 100 pounds gain are as follows:*

	Group X	Group XI
Protein (lbs.)	58.1	84.8
Total nutrients (lbs.)	279.7	331.5

It will be seen from this that Group XI, which received the reduced grain ration, required materially more digestible nutrients per 100 pounds of gain than Group X. Probably they were not able to handle so efficiently the increased bulkiness of the milk and hay.

After Group X had reached a weight of 148 pounds, which required 168 days, the pigs were placed on the self-feeder where they received no other grain than ground barley. Group XI was kept on the growing ration 189 days, at which time the average weight of the individual pigs had reached 149 pounds. While on the self-feeder both groups had access to alfalfa meal, but practically none was eaten. Group X was on the self-feeder 28 days and Group XI was on only 14 days. It would have been better for the experiment if the latter had been left on at least one more week so that the total weight would approximate 200 pounds. The detailed results are shown in Table VII.

Results.

During both the growing and fattening periods the pigs of Group XI made the more economical gains, so that the profit per pig of this group exceeded the profit from Group X as shown in Table VII. The cost of feed per hundred pounds gain for Group X was $6.84, and for Group XI it was $5.87. Even if the milk were charged at 25 cents per hundred instead of at 12½ cents the margin of profit would still be in favor of Group XI. See Table VII, p. 17.

Under the conditions of this experiment, 10 pounds of milk did not equal in feeding value one pound of barley for which it was substituted. It is probable that the ration received by Group X was already as bulky as the pigs could handle economically, and when a pound of barley was replaced by 10 pounds of milk the concentration of the ration was reduced to such an extent that the pigs could not make efficient use of the added milk.

The cost of barley, milk, and hay per pig are shown graphically in Chart II, page 18, and the profits are indicated by the height of the columns above the zero line.

Chart II shows cost of feed and profits per pig over feed costs from Groups X and XI. Group X received a 2% grain ration and 10% milk ration. Gains were credited at 10 cents per pound, grain was charged at 2 cents per pound, milk at 12½ cents per cwt., and hay at $10 per ton.

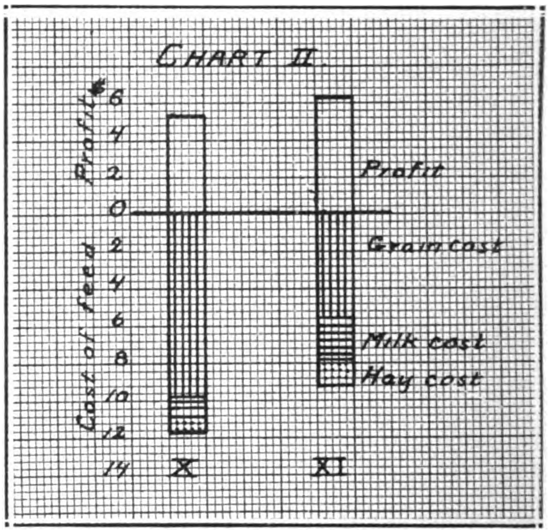
*Analyses from Henry and Morrisons "Feeds and Feeding," 16th Edition.

TABLE VII—PIGS ON ALFALFA HAY WITH VARYING MILK AND GRAIN RATIONS

Average Per Pig

	Growing period		Fattening period		Both periods	
	5% Milk 2% Barley	10% Milk 1% Barley	5% Milk Self-feeder	10% Milk Self-feeder	5% Milk	10% Milk
Group number	X	XI	X	XI	X	XI
Experiment begun	Nov. 13	Nov. 13	Apr. 30	May 21	Nov. 13	Nov. 13
Experiment ended	Apr. 30	May 21	May 28	June 4	May 28	June 4
Number of days	168	189	28	14	196	203
Initial weight (lbs.)	29.2	31.7	147.8	149.3	29.2	31.7
Final weight (lbs.)	147.8	149.3	201.2	188.4	201.2	188.4
Gain in weight (lbs.)	118.6	117.6	53.4	39.1	172.0	156.7
Daily gain (lbs.)	.71	.62	1.90	2.80	.88	.77
Daily gain (per cent)	.98	.83	1.30	1.67	1.02	.88
Grain fed (lbs.)	253	149	237.5	132.3	490.7	281.8
Grain per cwt. gain (lbs.)	213	127	445	338	285	180
Milk fed (lbs.)	635	1490	236	227	872	1718
Milk per cwt. gain (lbs.)	536	1268	442	579	507	1096
Alfalfa meal fed (lbs.)	175	284	....	....	175	284
Alfalfa meal per cwt. gain (lbs.)	148	241	....	....	102	181
Value grain @ 2¢ lb.	$5.06	$2.98	$4.75	$2.65	$9.81	$5.63
Value milk @ 12½¢ cwt.	.79	1.86	.30	.28	1.09	2.15
Value alfalfa meal @ $10 ton	.88	1.42	....	....	.88	1.42
Total value of feeds	$6.73	$6.26	$5.05	$2.93	$11.78	$9.20
Value of gain @ 10¢	$11.86	$11.76	$5.34	$3.91	$17.20	$15.67
Profit with hay charged	5.13	5.50	.29	.98	5.42	6.47
Profit with hay not charged	6.01	6.92	.29	.98	6.30	7.89

To calculate the feed bill for these two groups for any other combination of feed costs use Chart VII for Group X, and Chart VIII for Group XI.



PIG FEEDING EXPERIMENTS DURING THE SUMMER OF 1927

Plan of Experiment.

Thirty pigs, ranging in age from 8 to 10 weeks were divided into 6 groups, with 5 pigs in each group. The average weight per pig placed on experiment was 29.3 pounds. The groups were fed as follows:

Group	
XII	Alfalfa pasture and no milk.
XIII	Alfalfa pasture and 5% milk.
XIV	Alfalfa pasture and 10% milk.
XV	Alfalfa hay and no milk.
XVI	Alfalfa hay and 5% milk.
XVII	Alfalfa hay and 10% milk.

By this plan the value of alfalfa hay in the ration was compared with that of alfalfa pasture, and the value of milk as a supplement to the grain ration was determined. The pigs were left on the growing ration until they had attained an average weight of from 135 to 145 pounds, when they were placed on self-feeders and allowed to remain until the average weight was from 175 pounds to 190 pounds.

The area of pasture for each group was .14 acre, which would be 28 pigs per acre. The pasture seemed ample except for the "no milk" group, but it would be better to allow .2 acre to each group of five pigs. It was noticeable that the amount of alfalfa pasture eaten became less as the percentage of milk was increased.

Results.

It will be noted by reference to Tables VIII and IX that the rate of gain increased with the feeding of additional milk, and that the amount of grain decreased. The milk certainly resulted in a saving of grain

and shortened the time required to get the pigs ready for market. The results are reported in detail in Tables VIII and IX, pages 20 and 21.

The effect of milk in the ration on the rate of growth of the pigs during the growing and fattening periods is shown in the following table:

TABLE X—EFFECT OF MILK ON DAILY GAINS

Rations	Daily gain					
	Growing period		Fattening period		Both periods	
	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent
Alfalfa pasture, no milk	.67	.95	2.08	1.30	.82	1.00
Alfalfa pasture, 5% milk	.80	1.17	1.87	1.22	.95	1.18
Alfalfa pasture, 10% milk	.89	1.23	1.95	1.18	1.04	1.22
Alfalfa hay, no milk	.54	.79	1.78	1.10	.69	.83
Alfalfa hay, 5% milk	.72	1.02	2.38	1.43	.92	1.07
Alfalfa hay, 10% milk	.87	1.21	1.80	1.11	1.00	1.20

These results indicate that during the growing period milk greatly stimulates the growth, but during the fattening period it apparently had little or no beneficial effect. However, it is not possible to make an accurate comparison in this manner during the fattening period, since the various groups did not start into that phase of the experiment on an equal basis. To determine accurately the value of milk in the ration during this period would require a change in the plan of experiment whereby each group would be again subdivided into those receiving milk and others receiving no milk in the ration.

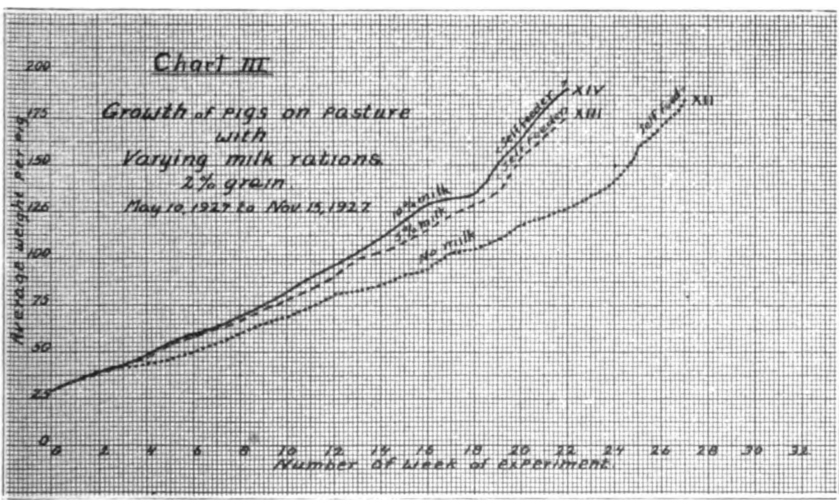


Chart III shows the effect of the addition of milk to the ration on the rapidity of growth of pigs in alfalfa pasture. All pigs receive 2% grain ration.

Group

XII...No milk in ration.
XIII......................................5% milk in ration.
XIV.......................................12% milk in ration.

TABLE VIII—PIGS ON ALFALFA PASTURE WITH VARYING MILK RATIONS

Amounts Given Are Averages Per Pig

	Group XII—Pasture and no milk			Group XIII—Pasture and 5% milk			Group XIV—Pasture and 10% milk		
	Growing period	Fattening period	Both periods	Growing period	Fattening period	Both periods	Growing period	Fattening period	Both periods
Experiment begun	May 10	Oct. 25	May 10	May 10	Sept. 20	May 10	May 10	Sept. 20	May 10
Experiment ended	Oct. 25	Nov. 15	Nov. 15	Sept. 20	Oct. 11	Oct. 11	Sept. 20	Oct. 11	Oct. 11
Number of days	168	21	189	133	21	154	133	21	154
Days per cwt. gain	150	48	121	124	53	105	112	51	96
Initial weight (lbs.)	29.1	141.0	29.1	29.2	136.2	29.2	29.2	147.6	29.2
Final weight (lbs.)	141.0	184.8	184.8	136.2	175.5	175.5	147.6	188.6	188.6
Gain in weight (lbs.)	111.9	43.8	155.7	107.0	39.3	146.3	118.4	41.0	159.4
Daily gain (lbs.)	.67	2.08	.82	.80	1.87	.95	.89	1.95	1.04
Daily gain (per cent)	.95	1.30	1.00	1.17	1.22	1.18	1.23	1.18	1.22
Grain fed (lbs.)	259.1	183.0	442.1	199.8	147.0	346.8	212.4	148.0	360.4
Grain fed cwt. gain (lbs.)	231.5	417.8	284.0	186.7	374.1	237.0	179.4	361.0	226.1
Milk fed (lbs.)	....	....	....	499.4	159.0	658.4	1058.7	346.6	1405.3
Milk fed cwt. gain (lbs.)	....	....	....	466.7	404.7	450.0	894.2	845.4	881.6
Value gain @ 10¢ lb.	$11.19	$4.38	$15.57	$10.70	$3.93	$14.63	$11.84	$4.10	$15.94
Value grain @ 2¢ lb.	5.18	3.66	8.84	4.00	2.94	6.94	4.25	2.96	7.21
Profit over grain cost	$6.01	$0.72	$6.73	$6.70	$0.99	$7.69	$7.59	$1.14	$8.73

TABLE IX—PIGS ON ALFALFA HAY WITH VARYING MILK RATIONS
Amounts Given Are Averages Per Pig

	Group XV—No milk			Group XVI—5% Milk			Group XVII—10% Milk		
	Growing period	Fattening period	Both periods	Growing period	Fattening period	Both periods	Growing period	Fattening period	Both periods
Experiment begun	May 10	Nov. 25	May 10	May 17	Oct. 18	May 17	May 17	Sept. 27	May 17
Experiment ended	Nov. 15	Dec. 20	Dec. 20	Oct. 18	Nov. 8	Nov. 8	Sept. 27	Oct. 18	Oct. 18
Number of days	196	28	224	154	21	175	133	21	154
Days per cwt. gain	185	58	146	138	43	109	115	55	100
Initial weight (lbs.)	29.2	134.8	29.2	29.6	141.0	29.6	29.4	145.3	29.4
Final weight (lbs.)	134.8	183.2	183.2	141.0	189.9	189.9	145.3	183.2	183.2
Gain in weight (lbs.)	105.6	48.4	154.0	111.4	48.9	160.3	115.9	37.9	153.8
Daily gain (lbs.)	.54	1.73	.69	.72	2.33	.92	.87	1.80	1.00
Daily gain (per cent)	.79	1.10	.83	1.02	1.43	1.07	1.21	1.11	1.20
Grain fed (lbs.)	282	257	539	233.7	176.6	410.3	201.7	161.0	362.7
Grain per cwt. gain (lbs.)	267	531	350	209.8	361.1	255.9	174.0	424.8	235.8
Milk fed (lbs.)				634.9	166.3	801.2	1008.4	331.2	1339.7
Milk per cwt. gain (lbs.)				569.9	340.1	499.8	870.0	874.0	871.0
Hay fed (lbs.)	204		204	152		152	93		93
Hay per cwt. gain (lbs.)	193		132	136		95	80		60
Value gain @ 10¢ lb.	$10.56	$4.84	$15.40	$11.14	$4.89	$16.03	$11.59	$3.79	$15.38
Value grain @ 2¢ lb.	5.64	5.34	10.78	4.67	3.53	8.21	4.03	3.22	7.25
Profit over grain cost	$4.92	-$0.50	$4.62	$6.47	$1.36	$7.82	$7.56	$0.57	$8.13

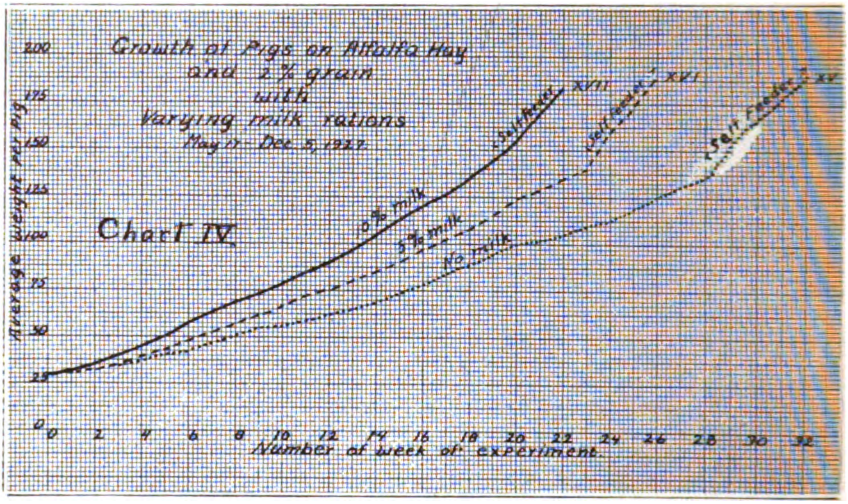


Chart IV shows the effect of the addition of milk to the ration on the rapidity of growth of pigs in dry lot. All pigs receive a 2% grain ration.

Group

XV...No milk in ration.
XVI..5% milk ration.
XVII...10% milk ration.

Value of Milk in Ration.

Milk in the ration does not have anything like a constant value. Its value fluctuates according to the price of the grains fed, the kind and value of the roughage included in the ration, the charge per hour for labor, and the per cent of milk fed. Milk increases in value with the rise in price of grain, roughage, and labor. Milk is worth less per hundredweight when fed in a 10 or 20 per cent than in a 5 per cent ration, as the pigs seem to make better use of it when fed to them in limited quantities. It is more essential to the growth of the pigs when they are in dry lot than when they are in pasture. Attempts have been made to evaluate milk as a hog feed, but these evaluations are practically worthless without giving at the same time details of the method used in securing them.

In order to give some idea of the value of milk as a hog feed, and to show variations in value, the following Table XI has been prepared from the results of the 1927 experiments, in which grain was charged at $2 per cwt., hay at $10 per ton, and labor at 40 cents per hour.

TABLE XI—VALUE OF SKIM MILK PER HUNDREDWEIGHT

	Pasture		Dry Lot	
	5% milk	10% milk	5% milk	10% milk
Calculated from saving of:				
Grain only	21	13	38	26
Grain and hay	25	17	41	30
Grain, hay and labor	32	23	56	41

Inspection of the above table makes it obvious that one cannot state the value of milk in the ration without at the same time describing the

method of making the calculations. Usually its value is stated in terms of the grain saved, but it also saves roughage and labor. With other conditions equal, the addition of milk to the ration shortens the time required to get the hogs ready to market and there is a marked saving in labor which should certainly be credited to the milk.

The full value of skim milk, based upon the saving of hay, grain, and labor, varied in the experiments reported above from 23 cents to 56 cents per hundredweight, with grain charged at $2 per cwt., but if grain is raised to $2.50 per cwt., the range in value of skim milk would vary from 26 to 65 cents. Likewise, a change in the cost of hay or labor would make necessary a recalculation of the milk values.

PIG FEEDING EXPERIMENTS DURING THE WINTER OF 1927–1928

Plan of Experiment.

In the previous experiments during the summer of 1927, the grain ration was constant to all groups and only the percentage of milk in the ration was varied, as the experiments were designed to give information in regard to the effect of milk in the ration on the economy of gains. During the winter of 1927–1928 the milk in the ration remained constant at 10% of the weight of the pigs, but the grain in the ration was varied so as to determine the economy of gains from light, medium, and heavy feeding of grain.

Fifteen pigs were divided into three groups of five pigs each, and fed rations as follows:

Group	
XVIII	2% grain for 16 weeks followed by self-feeder for 4 weeks.
XIX	4% grain for 16 weeks.
XX	Self-feeder for 12 weeks.

Tankage.

This was the first experiment having tankage added to the grain ration. The amount of tankage in the grain ration amounted to 6% to Group XVIII, 6.6% to Group XIX, and only 2.6% to Group XX. This latter group, which was fed throughout the experiment by self-feeder, had the tankage in a separate bin from the barley, and the pigs ate only as much as they desired. The other two groups were hand-fed, and the tankage equalled 10% of the grain for the first 10 weeks and then was reduced to 5% of the required grain ration in the succeeding weeks.

Results.

As would be expected, the rate of daily gain increased with the amount of grain fed, and the number of weeks required to get the pigs ready for market decreased. It took 19 weeks to get the 2% grain group to 180 pounds; 16 weeks for the 4% grain group; and only 12 weeks for the self-feeder group. The 2% grain group was actually fed for 20 weeks, but they had reached the average weight of 180 pounds at 19 weeks. The amount of grain required per pound gain was smallest for the 2% group and greatest for the self-feeder group, the amount required per pound gain being 2.6 pounds for the 2% group, 3 pounds for the 4% group, and 3.7 pounds for the self-feeder group. As the amount of grain eaten was increased the amount of alfalfa hay

TABLE XII—EFFECT OF ALFALFA PASTURE, ALFALFA HAY, AND VARYING MILK RATIONS ON FEED REQUIREMENTS OF HOGS

Results of 1927 Experiments

	No milk		5% Milk		10% Milk	
	Pasture	Hay	Pasture	Hay	Pasture	Hay
Experiment begun	May 10	May 10	May 10	May 17	May 10	May 17
Experiment ended	Nov. 15	Dec. 20	Oct. 11	Nov. 8	Oct. 11	Oct. 18
Number of days	189	224	154	175	154	154
Initial weight (lbs.)	29.1	29.2	29.2	29.6	29.2	29.4
Final weight (lbs.)	184.8	183.2	175.5	189.9	188.6	183.2
Gain in weight (lbs.)	155.7	154.0	146.3	160.3	159.4	153.8
Daily gain (lbs.)	.82	.69	.95	.92	1.04	1.00
Daily gain (per cent)	1.00	.83	1.18	1.07	1.22	1.20
Grain fed (lbs.)	442	539	347	410	360	363
Grain per cwt. gain (lbs.)	284	350	237	256	226	236
Milk fed (lbs.)	....	....	658	801	1405	1340
Milk per cwt. gain (lbs.)	....	....	450	500	882	871
Hay fed (lbs.)	....	204	....	152	....	93
Hay per cwt. gain (lbs.)	....	132	....	80	....	60

consumed was decreased so that the total nutrients required per pound gain was not widely different. It is apparent that the most economical gains were made with the 2% grain ration, even when the time required is taken into consideration and labor charged at 40 cents per hour. This same experiment is to be duplicated in both pasture and dry lot during the summer of 1928. The results are reported in detail in Table XIII.

TABLE XIII—HOG FEEDING EXPERIMENT
Average Per Pig. Winter of 1927–1928

	2% Grain 10% Milk	4% Grain 10% Milk	Self-feeder 10% Milk
Group number	XVIII	XIX	XX
Experiment begun	Nov. 22	Nov. 22	Nov. 22
Experiment ended	Apr. 10	Mar. 18	Feb. 14
Number of days	140	112	84
Initial weight (lbs.)	43.8	44.0	44.0
Final weight (lbs.)	198.0	184.2	180.0
Gain in weight (lbs.)	154.2	140.2	136.0
Daily gain (lbs.)	1.10	1.26	1.62
Daily gain (per cent)	1.09	1.29	1.69
Barley fed (lbs.)	376.8	394.0	495.0
Barley per cwt. gain (lbs.)	244	281	364
Tankage fed (lbs.)	23.2	28.0	13.4
Tankage per cwt. gain (lbs.)	15	20	10
Milk fed (lbs.)	1230	1056	1028
Milk per cwt. gain (lbs.)	798	753	756
Hay fed (lbs.)	146	54	19
Hay per cwt. gain (lbs.)	96	39	14

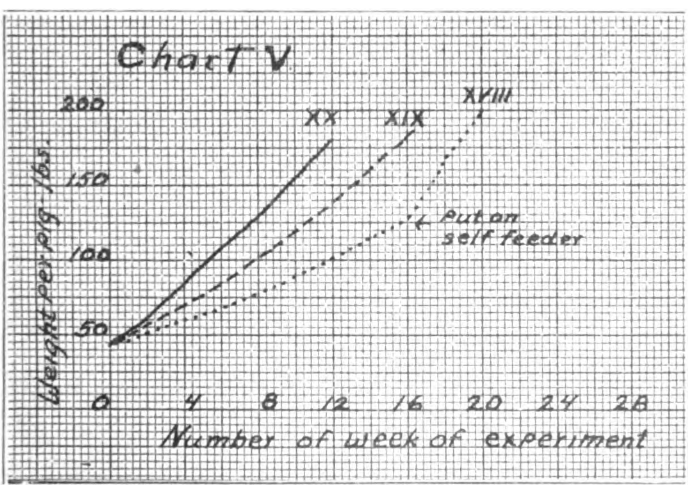
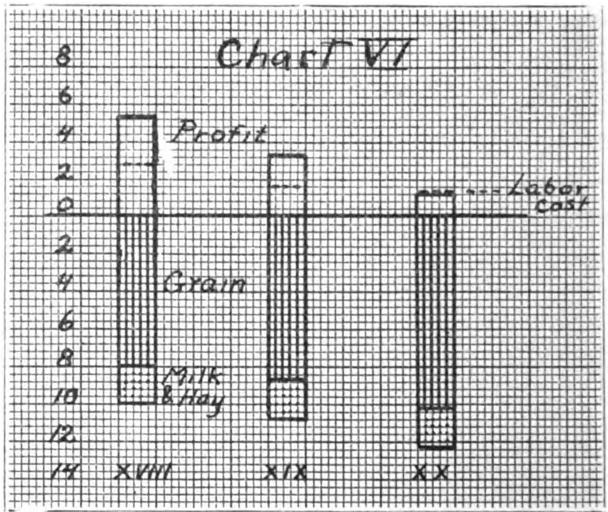


Chart V shows effect of amount of grain in the ration on rapidity of growth.

XX..Pigs on self-feeder.
XIX..................Pigs receiving 4% grain ration.
XVIII....Pigs receiving 2% grain ration for 16 weeks and on self-feeder for 4 weeks.

Chart VI shows effect of amount of grain in the ration on profit per pig when gains are credited at 10c., grain charged at 2c. per pound, milk at 20c. per cwt., and hay at $10 per ton. At these prices the heavy grain rations were least profitable.



EFFECT OF WEIGHT AND AGE ON ECONOMY OF GAINS

More grain is required per pound gain as the pigs grow older and heavier. Just after weaning, when they weigh 25 to 50 pounds, only 1.4 pounds grain was required per pound gain, but this requirement gradually increased up to the time they were transferred to the self-feeders at 150 pounds. At this time 2.9 pounds grain was required per pound gain.

TABLE XIV—EFFECT OF AGE OF HOGS ON ECONOMY OF GAINS

Pounds Grain Per Pound Gain

Age—Weeks	X	XI	XII	XIII	XIV	XV	XVI	XVII	Total	Average
8-12	1.7	1.0	1.4	1.2	1.1	2.2	1.4	1.2	11.2	1.4
12-16	1.7	1.0	1.6	1.6	1.5	1.7	1.5	1.3	11.9	1.5
16-20	1.9	1.4	1.7	1.7	1.7	2.8	2.1	2.0	15.3	1.9
20-24	1.9	.9	3.8	2.3	1.8	2.4	2.3	1.8	17.2	2.1
24-28	2.2	1.5	2.4	......	......	1.8	2.4	......	10.3	2.1
28-32	2.8	1.5	3.0	......	......	4.1	......	......	11.4	2.8

TABLE XV—EFFECT OF WEIGHT OF HOGS ON ECONOMY OF GAINS

Pounds Grain Per Pound Gain

Weight—Pounds	XII	XIII	XIV	XV	XVI	XVII	Total	Average
20-50	1.6	1.2	1.1	1.9	1.4	1.2	8.4	1.4
50-75	1.7	1.5	1.2	2.7	1.8	1.5	10.4	1.7
75-100	2.0	1.7	2.1	2.6	2.4	1.8	12.6	2.1
100-125	3.9	2.5	1.8	3.3	2.1	2.1	15.7	2.6
125-150	2.7	2.6	3.0	3.9	3.0	2.0	17.2	2.9

GRAIN AND MILK REQUIRED TO RAISE PIGS TO WEANING AGE

Five sows farrowed in the spring of 1927, producing 39 pigs, from which 30 of the largest were selected for the summer experiments. The feed given to the sows and pigs up to the time of weaning was recorded and is shown in Table XVI. The sows received all the alfalfa hay they would eat, but this was not weighed.

To raise a pig from birth to weaning at 9 weeks required 32.3 pounds of grain and 196 pounds of milk, in addition to an unknown amount of alfalfa hay. The average weight of the pigs at weaning time was 29.3 pounds each.

TABLE XVI—RATION OF AVERAGE SOW WITH LITTER OF 7.8 PIGS
Average of 5 Sows and 29 Pigs

Age of pigs, weeks	Ration per week		Ration per day		Nutrients per day	
	Grain pounds	Milk pounds	Grain pounds	Milk pounds	Crude protein	Total nutrients
1	13.65	143	1.95	20.4	.96	3.26
2	17.15	154	2.45	22.0	1.07	3.76
3	20.65	160	2.94	22.8	1.16	5.02
4	24.15	166	3.45	23.7	1.25	5.50
5	27.65	166	3.94	23.7	1.31	5.86
6	31.15	166	4.45	23.7	1.35	6.20
7	35.35	166	5.03	23.7	1.43	6.64
8	41.65	172	5.93	24.5	1.57	7.40
9	40.50	208	5.80	29.7	1.74	7.95
Totals	251.90	1501	35.94	214.2	11.84	51.59
Total per pig	32.30	192	4.60	27.5	1.52	6.60

NOTE—The alfalfa hay eaten in addition to the grain and milk is not included in this table.

ALFALFA HAY EATEN BY PIGS IN DRY LOT

It is interesting to know the amount of alfalfa hay a pig will eat in addition to the grain and milk. The amount varies inversely of course with the percentage of concentrates and milk they receive. The following table shows the amount of hay eaten by various groups:

Group	Ration	Hay eaten		Time of year
		Per pig, lbs.	Per cwt. gain, lbs.	
X	2% grain, 5% milk	175	102	Winter
XI	1% grain, 10% milk	284	181	Winter
XV	2% grain, no milk	217	132	Summer
XVI	2% grain, 5% milk	152	95	Summer
XVII	2% grain, 10% milk	93	60	Summer
XVIII	2% grain, 10% milk	146	96	Winter
XIX	4% grain, 10% milk	54	39	Winter
XX	Self-fed, 10% milk	19	14	Winter

Alfalfa was fed to Groups X and XI in the form of alfalfa meal. In general, it looks as if more hay was required for identical rations in winter than in summer.

PART II

THE ECONOMICS OF HOG PRODUCTION

CONSTANTLY CHANGING PRICES

In discussing the preceding experiments the costs of gains were calculated at fixed prices for grain and milk. The arbitrarily assumed price for grain was taken at 2 cents per pound, and no charge was made for labor or overhead. Now it is evident that prices are constantly fluctuating, both those that enter into the costs and those that are received for the hogs, so that any arbitrary combination of prices that may be adopted will be of little permanent value.

CALCULATED PROFITS OF ONLY TEMPORARY VALUE

In Chart II was shown the cost of feed per pig of Groups X and XI under one set of price conditions, but that chart is of no value when the farmer wishes to know the cost of feed and profits with grain, milk, or hay at other values. Again the statement of profits in Table VII is of only temporary value, for under a different set of price conditions the relative costs and profits will be altered and, under some conditions, profits will turn to losses.

USE OF TABLE IMPRACTICAL

Tables which would show all possible combinations of the prices which affect the costs and profits of the various hog experiments would require many pages, and would be impractical to use. The results of our feeding experiments with hogs are of practical use to farmers only in case the physical data are given in such a manner that calculations of feed and labor costs can be easily made at any time in the future. These physical data have been given in tables of the previous section, and the results can be adapted to new price conditions by making the necessary mathematical computations. However, in actual practice, these computations are almost never made by farmers, and the results of expensive investigations are often little used, and are, therefore, of comparatively little value because the results are too difficult to interpret in the light of changing conditions.

USE OF CALCULATING CHARTS

If tables or charts could be prepared that would simplify the work of calculating pork production costs of the various rations, the value of hog feeding investigations would be many times greater than they have been under the older system of making reports. In Bulletin 234 of the Illinois Agricultural Experiment Station, H. H. Mitchell has suggested the use of certain graphical methods for calculating the financial phases of feeding experiments. An adaptation of the charts shown by him makes possible the quick and easy calculation of feed bills, so that the probable cost of production of pork per hundredweight for any ration used in these experiments can be calculated in a moment for any combination of feed and labor costs. The intelligent use of

TABLE XVII—KEY TO FEED RATIONS REPRESENTED BY THE CALCULATOR CHARTS

Chart number	Season		Roughage		Grain percentage			Self-fed	Milk percentage		
	Winter	Summer	Pasture	Alfalfa hay	1%	2%	4%		0%	5%	10%
VII	X			X		X				X	
VIII	X			X	X						X
IX		X	X			X			X		
X		X	X			X				X	
XI		X	X			X					X
XII		X		X		X			X		
XIII		X		X		X				X	
XIV		X		X		X					X
XV	X			X		X					X
XVI	X			X			X				X
XVII	X			X				X			X

these charts should make possible the selection of that ration which will result in the most economical gains under the controlling price conditions of the moment.

VALUE OF COST CALCULATING CHARTS

These charts should be of value to farmers in determining the probable cost of gains of pigs that he is starting to feed under the price conditions of that particular season. He can, in this manner, make a fairly close estimate of the probable feed costs, and will know the price at which pork must sell in order to make expenses when the pigs are ready for market. With these charts the "Hog Outlook" for the coming season as prepared by the U. S. Department of Agriculture should have an added value, for the farmers will be able to adjust their type of rations to this forecast. The discussions later on in this bulletin show that rations should be modified to suit varying feed and pork prices. A combination that is most profitable under one set of grain and hog prices is not necessarily the most profitable under other sets of conditions.

HOW TO USE CHARTS TO CALCULATE FEED AND LABOR COSTS

Refer to Chart VII. Assume the following prices: Grain $2 per cwt., skim milk 10c. per cwt., hay $15 per ton, and labor 40c. per hour. The dotted lines are put in as a guide on this chart only.

1. Lay a ruler from the price of grain in scale A to the price of milk per hundredweight in scale B. Where the ruler crosses scale X make a pencil mark. This represents the cost of grain and skim milk per hundredweight gain. (In Chart VII the dotted line shows a cost of $6.20 for grain and milk).
2. Lay the ruler from the pencil point in scale X to the price of hay per ton in scale C, and make a light pencil mark where the ruler crosses scale Y. This point represents the cost of grain, milk and hay. (In Chart VII the dotted line shows a cost of $7 for grain, milk, and hay).
3. Lay the ruler from the pencil point in scale Y to the value of your labor per hour, and make a light pencil mark across scale Z. This point represents the full cost of feed and labor and is the price you should get per hundredweight for the hogs in order to get full pay for your labor and feed. (In Chart VII the full feed and labor cost is shown to be $9.20 per hundredweight gain. To this should be added a flat charge of $0.60 per cwt. to pay for taxes, overhead, depreciation, and upkeep of buildings and equipment, making a total cost per hundredweight gain of $9.80).

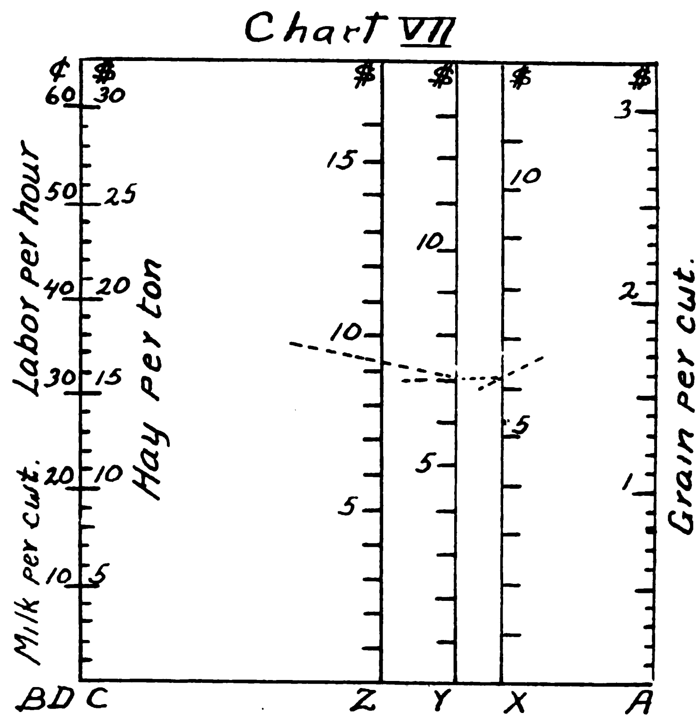


Chart VII is for calculating feed and labor costs of Group X.

Time.......Winter.

Ration....2% grain................................285 lbs. per cwt. gain.
5% milk................................507 lbs. per cwt. gain.
Alfalfa meal........................102 lbs. per cwt. gain.

Labor.....196 days................................5.7 hrs. per cwt. gain.

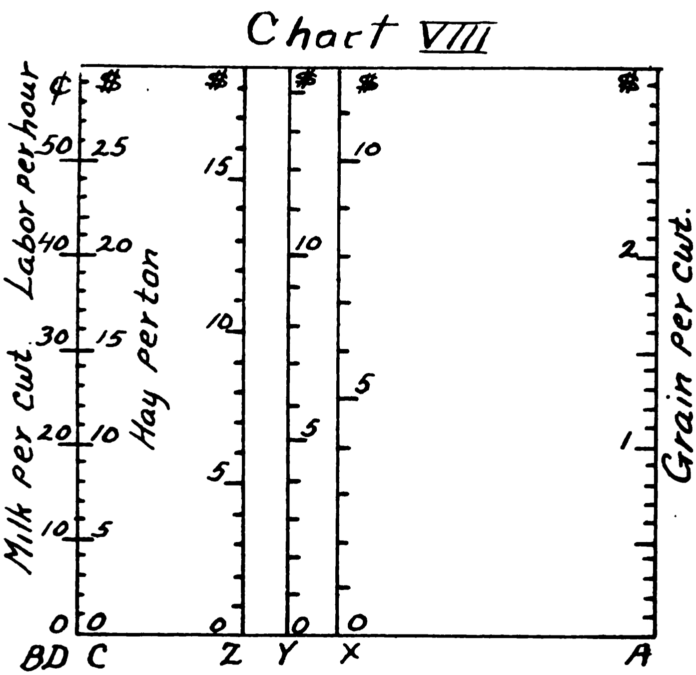


Chart VIII is for calculating feed and labor costs of Group XI.

Time.......Winter.

Ration....1% grain.............................. 180 lbs. per cwt. gain.
10% milk............................1096 lbs. per cwt. gain.
Alfalfa meal....................... 181 lbs. per cwt. gain.

Labor.....203 days............................... 6.5 hrs. per cwt. gain.

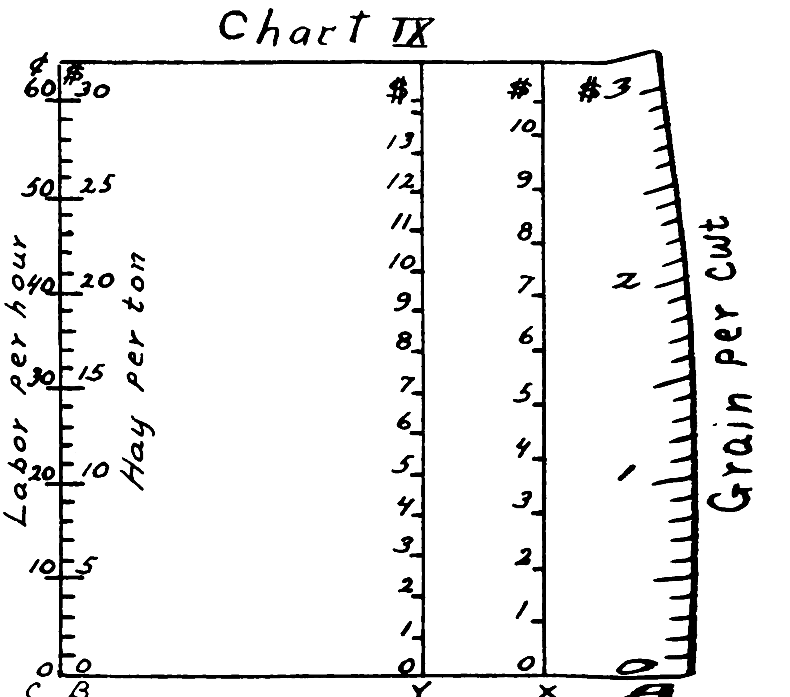


Chart IX is for calculating feed and labor costs of Group XII.

Time	Summer.		
Ration	2% grain	284 lbs. per cwt.	gain.
	No milk	0 lbs. per cwt.	gain.
	Alfalfa pasture (Hay equivalent)	132 lbs. per cwt.	gain.
Labor	189 days	6.05 hrs. per cwt.	gain.

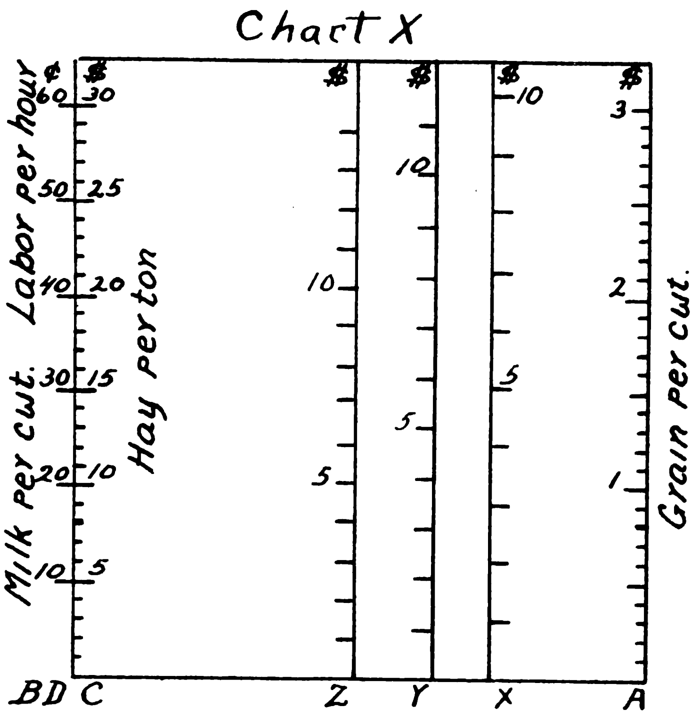


Chart X is for calculating feed and labor costs for Group XIII.

Time.......Summer.

Ration....2% grain.............................. 237 lbs. per cwt. gain.
5% milk............................... 450 lbs. per cwt. gain.
Alfalfa Pasture................ 95 lbs. per cwt. gain.
(Hay equivalent)

Labor.....154 days...............................5.25 hrs. per cwt. gain.

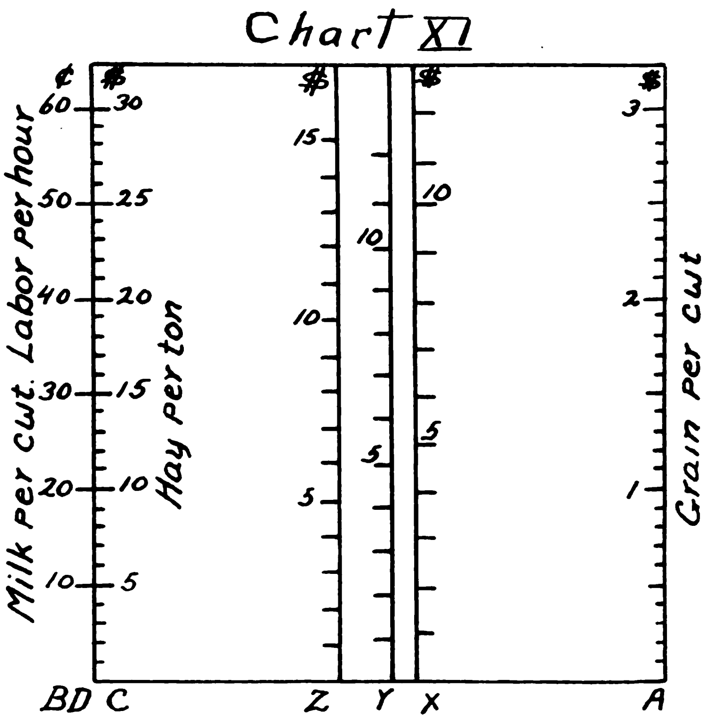


Chart XI is for calculating feed and labor costs of Group XIV.

Time.......Summer.

Ration....2% grain	226.1	lbs. per cwt. gain.
10% milk	881.6	lbs. per cwt. gain.
Alfalfa pasture (Hay equivalent)	60	lbs. per cwt. gain.
Labor.....154 days	4.8	hrs. per cwt. gain.

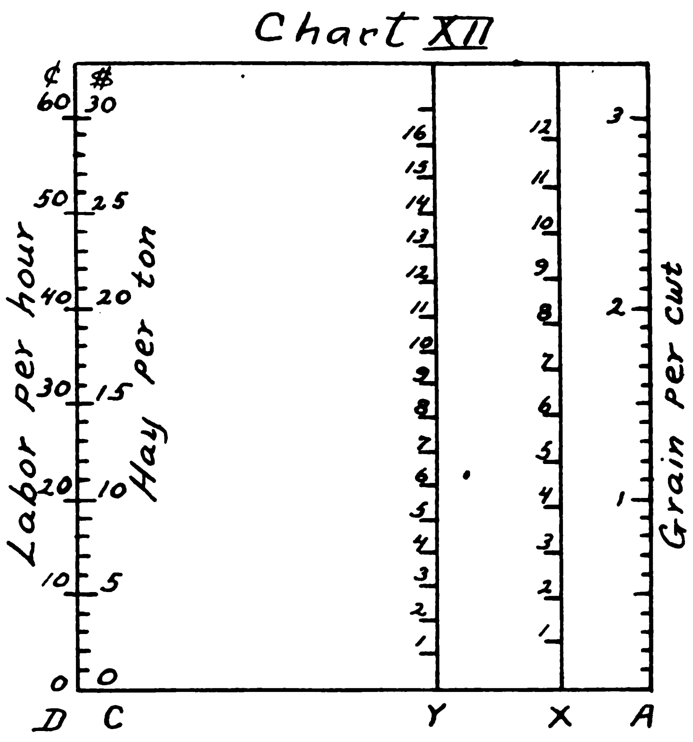


Chart XII is for calculating fed and labor costs of Group XV.

Time.......Summer.

Ration....2% grain............................... 350 lbs. per cwt. gain.
No milk................................ 0 lbs. per cwt. gain.
Alfalfa hay......................... 132 lbs. per cwt. gain.

Labor.....224 days............................... 7.3 hrs. per cwt. gain.

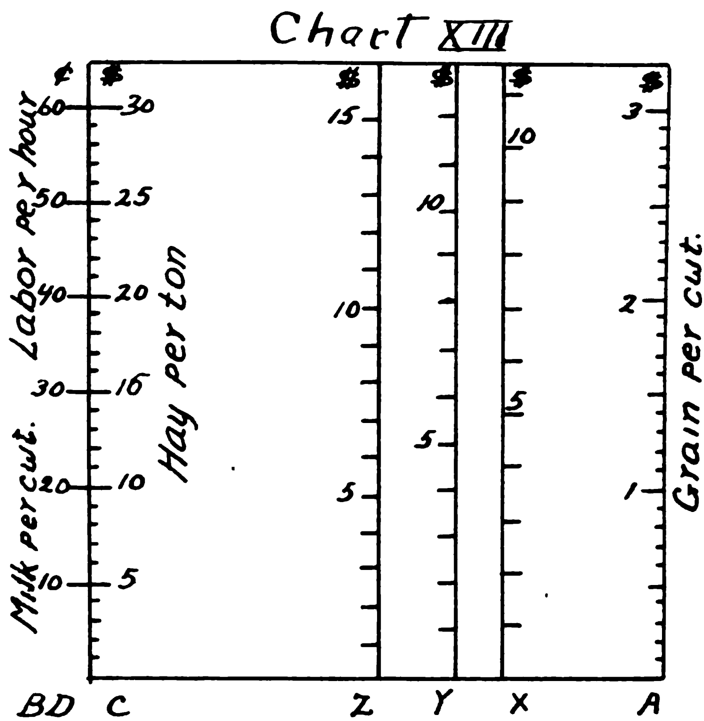


Chart XIII is for calculating feed and labor costs of Group XVI.

Time	Summer.		
Ration	2% grain	255.9	lbs. per cwt. gain.
	5% milk	500	lbs. per cwt. gain.
	Alfalfa hay	95	lbs. per cwt. gain.
Labor	175 days	5.45	hrs. per cwt. gain.

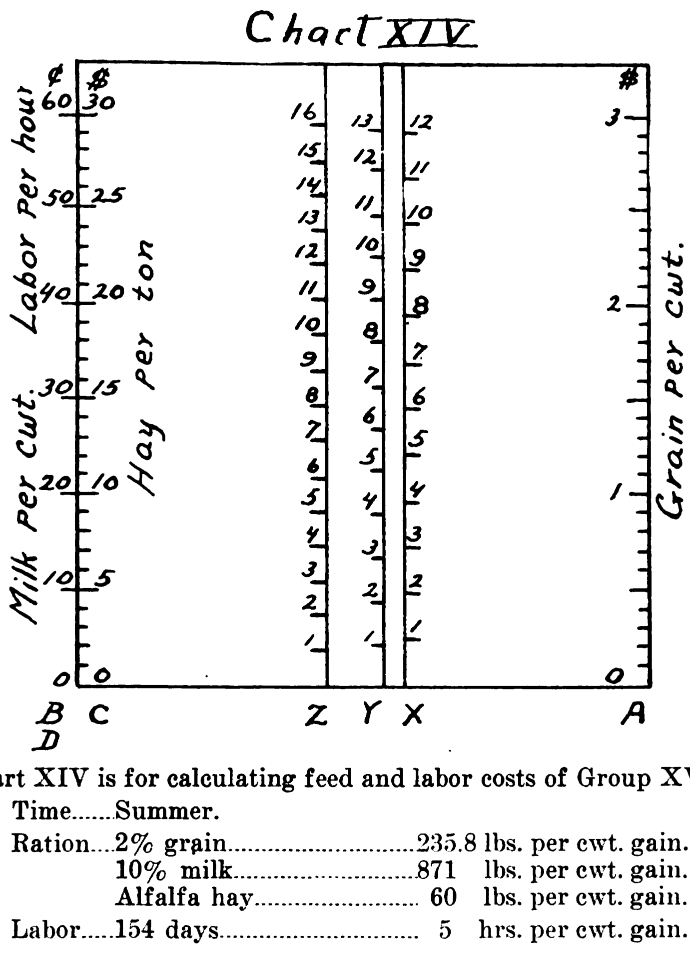


Chart XIV is for calculating feed and labor costs of Group XVII.

Time......Summer.			
Ration....2% grain	235.8	lbs. per cwt. gain.	
10% milk	871	lbs. per cwt. gain.	
Alfalfa hay	60	lbs. per cwt. gain.	
Labor.....154 days	5	hrs. per cwt. gain.	

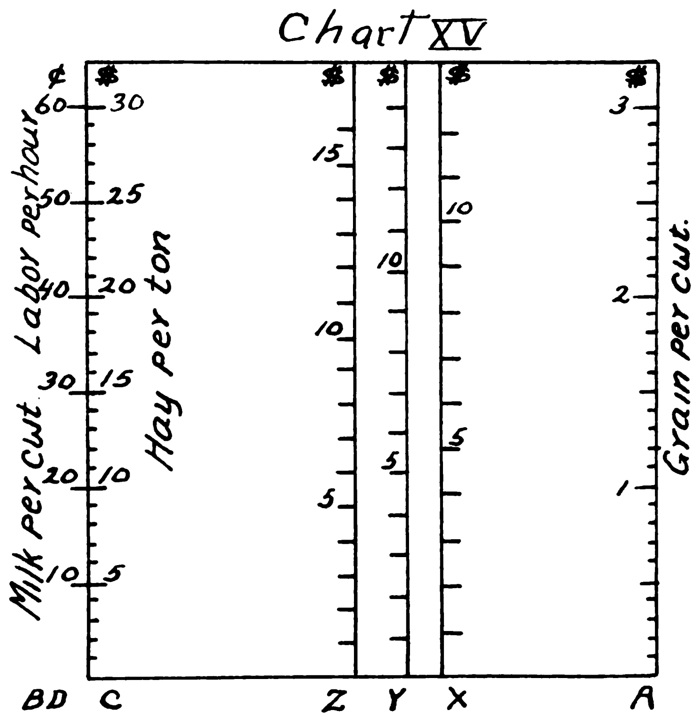


Chart XV is for calculating feed and labor costs of Group XVIII.

Time.......Winter.

Ration...	2% grain............................	259 lbs. per cwt. gain.*
	10% milk............................	798 lbs. per cwt. gain.
	Alfalfa hay........................	96 lbs. per cwt. gain.
Labor.....	140 days..............................	4.55 hrs. per cwt. gain.

*Includes 15 lbs. tankage.

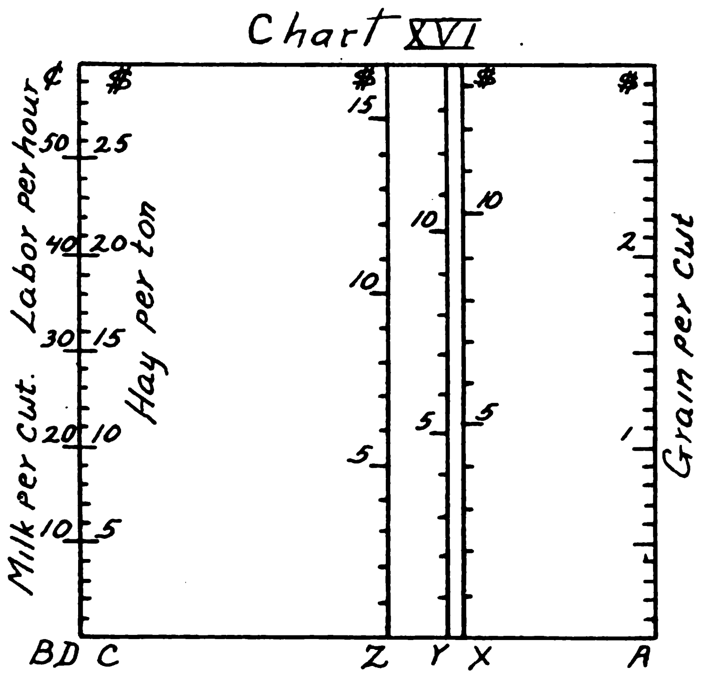


Chart XVI is for calculating feed and labor costs of Group XIX.

Time.......Winter.

Ration....4% grain	....	301 lbs. per cwt. gain.*
10% milk	....	753 lbs. per cwt. gain.
Alfalfa hay	....	39 lbs. per cwt. gain.
Labor.....112 days	....	4 hrs. per cwt. gain.

*Includes 20 lbs. tankage.

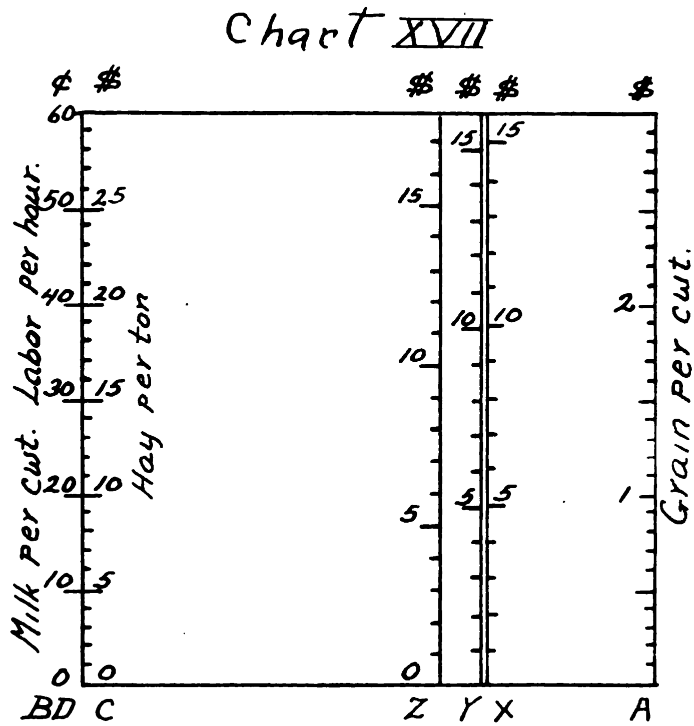


Chart XVII is for calculating feed and labor costs of Group XX.

Time......	Winter.	
Ration...	Grain* from self-feeder....	374 lbs. per cwt. gain.
	10% milk..............................	756 lbs. per cwt. gain.
	Alfalfa hay..........................	14 lbs. per cwt. gain.
Labor.....	84 days................................	3.1 hrs. per cwt gain.

*Includes 10 lbs. tankage per cwt. gain.

HOW THE CALCULATING CHARTS MAY BE USED

Example No. 1.

A farmer has litters of early spring pigs and wishes to find the most economical ration and the probable profit or loss. Assume the present value of rolled barley to be $1.75 per cwt., milk 15 cents per cwt., hay $8 per ton, and the value of labor 40 cents per hour. The farmer notes that the present price of hogs is 8 cents and that the hog outlook, as given by the U. S. Department of Agriculture, is only slightly optimistic. At least no decline in prices is looked for. Which is the most economical ration to use, and is there a fair chance of making a profit?

By referring to Table XVII it can be seen at a glance that there were 6 summer-fed groups, 4 of which received milk in the ration. The charts corresponding to the milk-fed groups are numbers X, XI, XIII, and XIV. Calculations from these four charts on the basis of the prices above, indicate costs per hundredweight gain as follows:

Rations	Cost of Feed	Cost of Feed and labor
5% milk, pasture, 2% grain	$5.20	$7.30
10% milk, pasture, 2% grain	5.50	7.44
5% milk, hay, 2% grain	5.60	7.80
10% milk, hay, 2% grain	5.70	7.70

It is evident that the cheapest gains will be made on alfalfa pasture and that there is little choice between the 5% and 10% milk ration. When 60 cents overhead is added on to the feed and labor costs, it brings the total cost of producing gains up to $7.90 per cwt., which means that with hog prices remaining stationary the farmer will secure a fair market for his feed and labor. If the price of hogs should rise, a dividend will be obtained over and above the cost of production.

Example No. 2.

In the fall of the year let us assume that a farmer finds prices to be as follows: Grain $2, milk 15c., hay $10, and labor 40c. The present price for hogs is 8½c. but the outlook as reported by the U. S. Department of Agriculture is decidedly optimistic. What are the chances of securing profitable returns?

By looking at Table XIV it is seen that the calculating charts for the winter-fed groups are VII, VIII, XV, XVI, and XVII. Calculations made from the charts for these groups show production costs at current prices to be as follows:

Chart	Rations	Cost per cwt. gain of Feed	Cost per cwt. gain of Feed and labor
VII	2% grain, 5% milk	$7.00	$9.25
VIII	1% grain, 10% milk	6.15	8.75
XV	2% grain, 10% milk	6.85	8.70
XVI	4% grain, 10% milk	7.35	8.95
XVII	Self-fed, 10% milk	8.70	9.90

It is apparent that full returns for labor cannot be secured if the price of hogs should not rise above $8.50 per cwt., but the pigs can be fed by any of the first four methods without an actual loss on feeds. Either the 1% or 2% grain plus 10% milk ration appears to be the most economical to use under these conditions. Since the outlook report indicated a possible advance in prices, the farmer would be justified in taking a chance on carrying the pigs to maturity, knowing that even if no advance in hog prices occurred there would still be a profit over the feed costs. The only sacrifice would be that he would not receive the full 40 cents per hour for his labor.

FACTORS AFFECTING COST OF PRODUCTION AND PROFIT

Market Price of Pork.

The most obvious variable factor affecting profits is, of course, the price per pound received for the hogs when they are marketed. This price is under the control of the farmers only to a very limited extent, and that is by the finish, quality, weight, and season of the year when marketed. In some of the local Nevada markets even these factors are

not taken into consideration, and the farmer who produces hogs of the highest quality receives no more per pound than does the farmer who markets ill-fed, unfinished hogs. This, of course, is a condition that should be corrected. Those who produce hogs in sufficient number to ship to the coast markets can, however, control to a slight extent the price received.

Seasonal Price Fluctuations.

The average market price varies from month to month and is usually highest in August and lowest in November. The average price paid for hogs on the San Francisco markets is shown by the graph on Chart XVIII. It is evident that when early spring pigs are dropped it would generally be most profitable to force the feeding so they could be marketed in August or September, for if they are fed a limited ration and are not ready for market until October or November the price received per pound will on the average be from one to two cents lower. Forced feeding may slightly increase the cost per pound gain. but when feeding January or February pigs this increased cost may usually be disregarded, as it will be more than offset by the advance in price of the hogs. The seasonal price changes for barley are not sufficiently great to be worth taking into consideration.

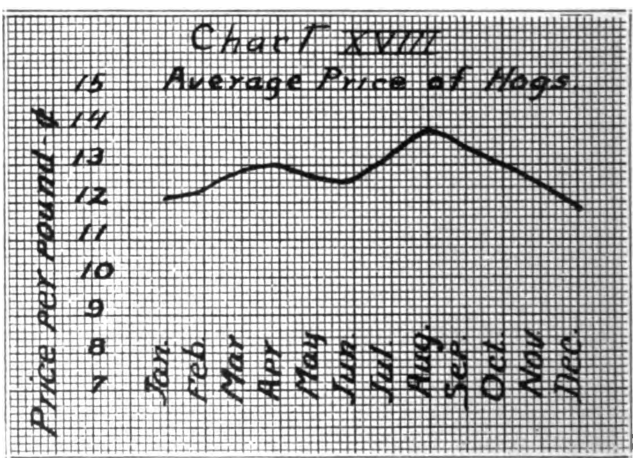


Chart XVIII, curve showing average monthly price paid for hogs in the San Francisco markets. Years averaged, 1918–1927. Note that the peak prices are received in April and August, and the lowest average monthly price is in December.

Market Price of Grain.

The next most powerful factor influencing profits is the market price of the grain fed. The grain should be charged against the hogs at the price the farmer pays, or at the price he would receive if the grain were marketed. The only control the farmer has over this price is in the selection of the kind of grain. Either corn or barley may be used, and the one should be selected which costs least per pound, except that when the prices are approximately equal the preference should be given

to corn. The grain requirements of hogs are less in summer than in winter, so that less grain is necessary to produce pork in summer than in winter.

Value of Hay and Milk.

The value placed on hay has little effect upon the cost of production except when very limited grain rations are fed. The value placed upon the milk, however, has a marked effect on the cost of gains, as milk may constitute a large part of the hog ration. A value should be placed on the skim milk even though it has no cash market value. Feed and labor have been expended in producing and caring for it, and the dairy herd should be given fair credit for this as well as for the butterfat. Where skim milk or buttermilk has a cash value it usually ranges from one to two cents a gallon (11½ to 23 cents per cwt.).

Value of Labor.

The time required to finish pigs varies according to the efficiency of the ration. Whenever the grain or milk in the ration is reduced, the time required to fatten the pigs is increased, and with it the labor cost. The rate that is charged per hour for labor may vary somewhat, but it should be sufficient to cover the average cost per hour of hired labor plus the cost of board.

Overhead Costs.

These costs are made up of taxes, equipment and building upkeep and depreciation, miscellaneous, veterinary and medicine costs. The average overhead cost per hundredweight of hogs produced on private farms in western Nevada was found to be 64 cents. For this report a flat rate of 60 cents per cwt. is used by adding it to the cost of feed and labor as found on the calculating charts.

Definition of the Term "Profit."

The term "profit" is used in a great variety of ways when applied by farmers to the financial outcome of their enterprises. Very frequently it is used to designate the amount received over the value of the grain fed, no account being taken of the milk, hay, and labor. In this report hogs are considered profitable if the sale value of the hogs produced is equal to the cost of grain, milk, hay, labor, and overhead. Profits received above these costs may be termed dividends. If the income is just equal to these costs, it means that the farmer has sold his grain, hay, milk, and labor to the hogs at prevailing market prices. When these conditions are fulfilled the enterprise is profitable and is an asset to the farm. If the income is less than these combined costs, the farmer is receiving a *reduced* labor income, which is somewhat less than the prevailing wage rate. There is a "loss" or *minus* labor income only when the feed and overhead costs are greater than the gross income so that the farmer receives less than nothing for his labor. There is an *excess* labor income or dividend when the gross returns are greater than all the calculated costs including labor at current rates.

For example: Note the dotted lines on Chart VII. The cost of feed alone is $7 per cwt. gain, so there would be a minus labor income with hogs selling at less than 7 cents. The cost of feed and labor is $9.25 per cwt., so there would be excess labor income with hogs at 10 cents.

CONCLUSIONS

1. Milk is always a profitable addition when added to the hog ration, whether charged at 10 or 20 cents per hundredweight.

2. Milk is worth more to pigs on alfalfa hay than to those on alfalfa pasture. Something appears to be supplied by the pasture that is lacking in the dry lot. This deficiency is supplied in part at least by the milk.

3. In winter feeding a ration limited to 2% grain resulted in more economical production than when a 4% grain ration was given or when the self-feeder was used. A limited ration is probably best during the growing period, but a self-feeder should be used during the fattening period.

4. When the price of grain goes up or the price of hogs goes down the effect is to increase the money value of the milk.

5. Under the conditions of these experiments and with labor charged at 40 cents per hour the hogs can be produced profitably:

(a) At 7½c. when grain is $1.50 or less and milk charged at 10c. per cwt.

(b) At 8c. when grain is $1.50 and milk does not exceed 20c. per cwt.

(c) At 9c. when grain is $2 or less and milk does not exceed 20c. per cwt.

(d) At 10c. when grain is $2.50 or less and milk does not exceed 20c. per cwt.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 115 RENO, NEVADA July, 1928

THE GREASEWOOD

(*Sarcobatus vermiculatus*)

A Range Plant Poisonous to Sheep

By

C. E. FLEMING

Assisted by

M. R. MILLER and Dr. L. R. VAWTER

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

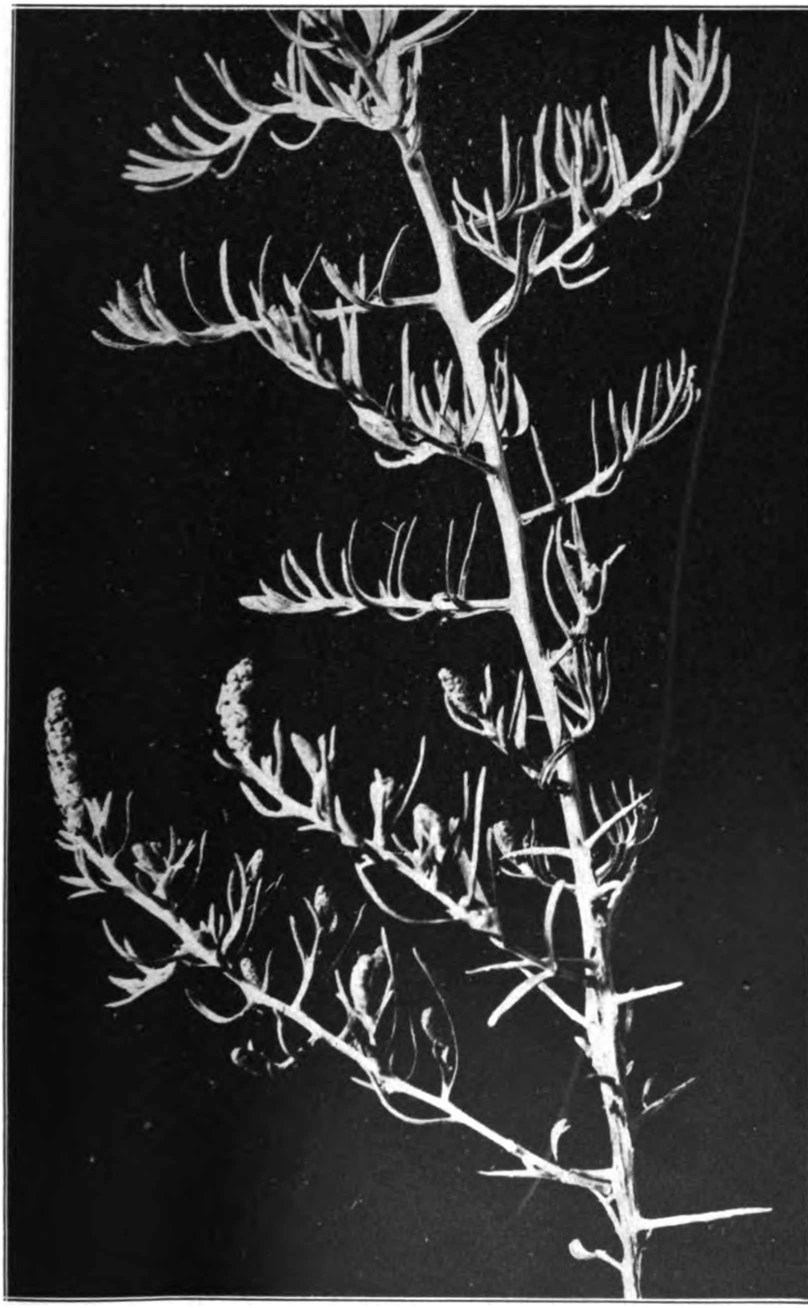
166

NEVADA AGRICULTURAL EXPERIMENT STATION

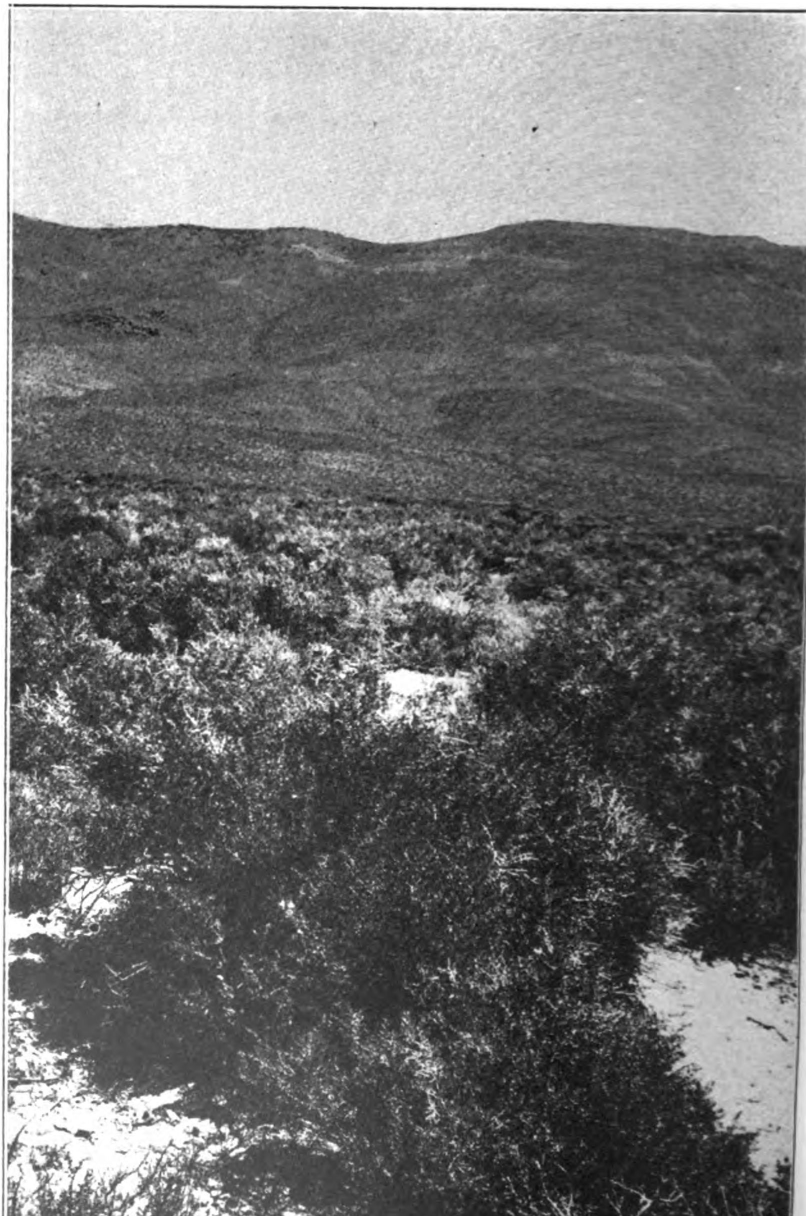
BOARD OF CONTROL

OFFICERS

STAFF



A Twig of Greasewood (Sarcobatus vermiculatus). Natural Size.



A Greasewood Grazing Range.

THE GREASEWOOD AS A RANGE PLANT POISONOUS TO SHEEP

On the grazing ranges of the west the greasewood has been and is now regarded by many livestock men as a valuable source of range feed, particularly for sheep. There are spring lambing grounds where the greasewood supplies a large portion of the daily ration of the ewes. Many flocks of ewes are grazed without apparent injury during most of the lambing period on ranges where the main source of feed is the greasewood.

However, this plant came under suspicion in Nevada as early as 1916. Finally, late in May, 1921, it was first reported to the Experiment Station as having caused the death of both sheep and cattle in a region near Panaca, in Lincoln County. Since then similar reports have come in from Lyon and Churchill Counties.

In May, 1921, a flock of sheep was being trailed out of Nevada into Utah. The sheep had been traveling over an area of range where good feed was scarce. From this region of scanty feed they came suddenly upon a large area supporting greasewood in abundance. The greasewood at that time of year was at the stage of growth in which the young tender shoots were two to three inches long. The abundance of this luxuriant, juicy, new growth permitted the sheep to satisfy their hunger quickly. Within a period of six to ten hours a large number showed distinct signs of poisoning in varying degrees of severity.

The symptoms gradually became more acute and many of the poisoned animals fell and were unable to get up. The sheep which could be driven were then started to trail toward the Utah line. The next day along the area over which the sheep had trailed there were many poisoned animals. At this time the cause of the death of the animals could not be definitely assigned, although it was believed to be either the greasewood or else poisoned water. Subsequent feeding tests have definitely established the fact that the greasewood poisoned and killed the sheep in this particular case.

Several other livestock losses have been reported where all the circumstances made it appear that the greasewood was responsible for the death of the animals. As a result of these unusual losses, feeding tests were started in 1918 to investigate the apparent poisonous properties of the greasewood. These feeding tests, together with interpretations of their meaning and general range observations concerning the greasewood, are reported in this bulletin.

GREASEWOOD RANGES

The greasewood within the State of Nevada is widely and abundantly distributed, but it does not cover a large acreage of the State in comparison with such plants as the saltbush, rabbit brush, and sagebrush. It is found growing on ranges where, due to seepage and drainage water, there is a high water table during at least the spring months, and where the so-called alkali salts have accumulated in sufficient quantities to allow only alkali-resisting plants to grow freely.

The greasewood is frequently associated with other shrubs and alkali-enduring plants. There are, however, pure stands of it found on ground when the water table is too high and persistent to permit such plants as the saltbush and rabbit brush to grow.

Greasewood ranges present several different appearances, depending upon the associated plants. A typical association is that made up of greasewood and rabbit brush (*Chrysothamnus*). Another association frequently found covering large acreages is composed of greasewood and saltbush or shadscale (*Atriplex*). Further there are areas in which the greasewood, rabbit brush, and saltgrass make up almost the entire composition. There is also the seepweed (*Dondia*)-greasewood association which occupies quite limited areas in comparison with the other acreages on which greasewood is abundant. The seepweed-greasewood association usually indicates a soil with a high salt content.

DESCRIPTION OF PLANT

The greasewood belongs to that group of plants generally known as the goosefoot family (*Chenopodiaceæ*). This family contains several plants quite familiar to the range livestock man. It includes such shrubs and shrub-like plants as the hop sage (*Grayia*), white sage or winter-fat (*Eurotia*), and saltbush, some species of which are commonly referred to as shadscale (*Atriplex*).

The greasewood is botanically known as *Sarcobatus vermiculatus*. The word *Sarcobatus* is made up from the Greek *sarkos* meaning fleshy and *batos* meaning thorn, which briefly describes the plant; thorny stems and fleshy leaves.

The greasewood is a shrub growing from one to six feet high, with spreading spiny branches and narrow fleshy leaves without lobes or teeth or divisions of any sort. The leaves are borne in an alternate manner, being seated on the twigs without stalks. During the spring months the foliage is a clear dark green, which presents a decided contrast to the gray and silvery gray of the sagebrush and saltbush. As the season advances the leaves of the greasewood take on a rusty red color and become less juicy and tender.

During the fall and early winter months the leaves become dry and fall to the ground; the general appearance of the plant is then that of a leafless spiny shrub.

EXPERIMENTAL FEEDING TESTS WITH SHEEP

The sheep used in the feeding tests were ewes, the larger number of which were born and raised on the range. They were fed the greasewood leaves in two ways, (1) by voluntary feeding, and (2) by placing the green leaves and tender stems in their mouth and then allowing the sheep to chew and swallow them naturally.

The following table gives the results of feedings made for the purpose of determining the amounts of greasewood leaves necessary to poison an average range sheep. In order to eliminate the question of time all of the sheep used in this series of feeding tests were fed by putting a small quantity of the green leaves and stems into the mouth: just as soon as the leaves and stems were chewed and swallowed, similarly small quantities were placed in the mouth until the required

amount had been eaten. This method of feeding took from about thirty minutes to an hour, depending on the quantity fed:

GREASEWOOD LEAVES FED TO DETERMINE AMOUNTS REQUIRED TO MAKE SICK OR KILL

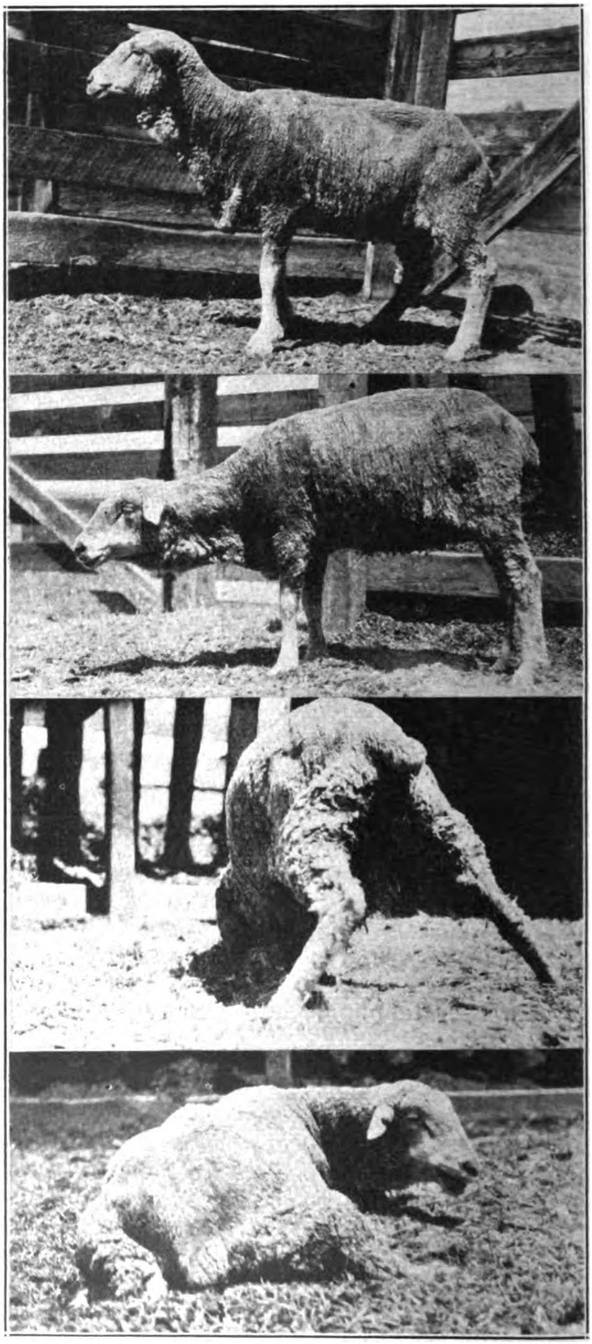
Date fed	Weight of animal, pounds	Amount fed lbs.	Amount fed ozs.	Results	Ozs. fed per 100 lbs. live weight	Per cent fed of live weight	Lbs. fed per 100 lbs. live weight
7-24-25	108	5	0	Death	77.6	.0485	4.85
6-13-18	111	5	0	Death	72.0	.045	4.50
7-19-18	97	4	9	Death	75.2	.047	4.70
5-19-26	95	4	12	Death	80.0	.05	5.00
9-12-26	93	4	8	Death	77.4	.048	4.83
9-14-26	101	5	0	Death	79.2	.0495	4.95
9- 1-26	110	5	8	Death	80.0	.05	5.00
9-22-26	99	5	12	Death	92.9	.058	5.80
9- 6-26	93	5	9	Death	95.7	.0598	5.98
7-18-25	115	10	0	Death	139.1	.0869	8.69
6-16-26	102	6	12	Death	105.8	.0661	6.61
6-19-26	131	6	8	Death	79.3	.0496	4.96
6-18-26	104	5	11	Death	87.5	.0546	5.46
5-27-26	109	7	12	Death	113.7	.0711	7.11
9-14-26	79	4	9	Death	92.4	.0577	5.77
7-21-25	126	7	0	Death	88.8	.0555	5.55
6-17-26	92	4	9	Sick	79.3	.0495	4.95
5-25-26	96	5	14	Sick	97.9	.0611	6.11
9-18-26	102	5	0	Sick	78.4	.049	4.90
5-24-26	108	5	15	Sick	87.9	.0549	5.49
9- 2-26	89	5	7	Sick	97.7	.0611	6.11
5-18-26	115	5	3	Sick	72.1	.0451	4.51
5-20-26	96	4	13	Sick	80.2	.0501	5.01
5-21-26	111	5	9	Sick	80.1	.0501	5.01
7-28-25	113	4	0	Sick	56.6	.0353	3.53
6-13-18	120	2	4	Negative	30.0	.0187	1.87
7-14-25	105	5	4	Negative	80.0	.05	5.00
6-19-18	87	4	0	Negative	73.5	.0459	4.59
7- 8-25	105	2	8	Negative	38.0	.0238	2.38
6-23-26	90	3	10	Negative	64.4	.0402	4.02
9-14-26	112	5	10	Negative	80.3	.0502	5.02
5-17-26	108	4	3	Negative	62.0	.0387	3.87
6-19-26	102	4	1	Negative	63.7	.0398	3.98
5-20-26	110	4	6	Negative	63.6	.0397	3.97
7- 7-26	114	4	8	Negative	63.1	.0394	3.94
8-21-26	112	4	10	Negative	66.0	.0413	4.13

(1) The above table shows that out of the 36 feedings made, 16 produced death, nine caused sickness, and eleven failed to affect the animal noticeably.

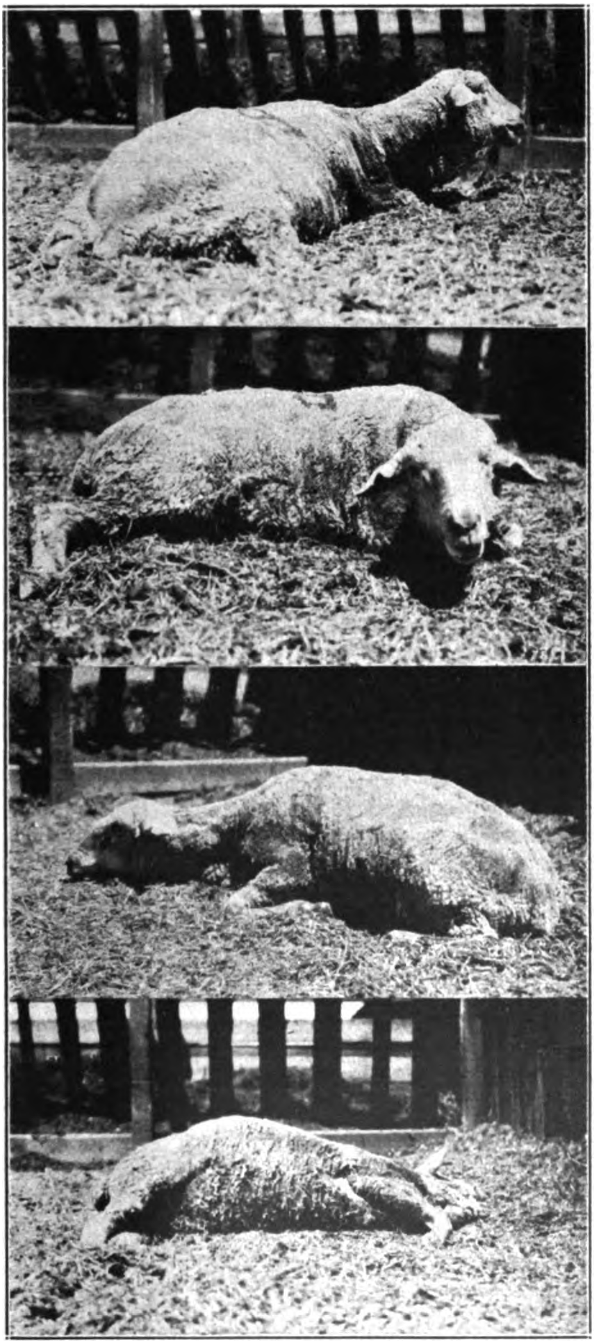
(2) When an average is taken of all the above feeding tests, we find that for each 100 pounds of the animal's live weight, it took 5.61 pounds of the leaves to cause death, 5.06 pounds to produce poisoning symptoms followed by recovery, while feedings of 3.88 pounds failed to cause any poisoning symptoms that could be detected.

(3) The smallest fatal amount in all of the 16 feedings that caused death was 4.50 pounds of leaves to each 100 pounds of the animal's live weight, while among the feedings causing poisoning symptoms we find that the smallest fatal dose was 3.53 pounds. The table shows three feedings of more than four pounds and two above five pounds of leaves for each 100 pounds of live weight that failed to cause any apparent symptoms of poisoning. These irregularities show that the individuality of the animal and its condition influence the degree to which it is subject to this form of poisoning.

(4) A study of all the feeding tests shows that there is little difference in the amount of greasewood leaves required to cause either sickness with recovery or sickness followed by death. This amount is



Early Stages of Greasewood Poisoning.



Later Stages and Death.

approximately 5 per cent of the live weight of the animal in greasewood leaves when taken into the stomach within a period of thirty minutes to an hour.

(5) Feedings were made from May to September. During this period the greasewood was the least poisonous during the early spring months. This statement is based upon the quantity that must be eaten in order to cause symptoms of poisoning. In the spring the leaves have a higher moisture content than later in the season. and this probably accounts in part for the apparent lower toxicity during this period of the year.

A FATAL CASE OF POISONING IN DETAIL

The illustrations show a series of eight consecutive photographs of a poisoned ewe depicting the various stages of fatal greasewood poisoning.

This ewe weighed 103½ pounds. She was fed 6½ pounds of greasewood leaves June 6, 1928, between 2:45 a.m. and 4:55 a.m. At 10 a. m. the first signs of poisoning were detected, and at 12:40 p. m. the same day she died.

The first picture shows her to be a normal range ewe, alert and half wild, twelve hours before the fatal feeding of greasewood.

The second picture shows this ewe at 10 a. m. The first symptoms of poisoning have appeared in the form of drowsiness and a disinclination to move when approached or urged. The wild alertness acquired by living on the open range has entirely disappeared, and listlessness has taken its place.

A little later, beginning at 10:25 a. m., as shown in the next two pictures, leg weakness has developed and has progressed to the point where she is unable to stand. She falls head first, and a little later lies sprawling and unable to get on to her feet again.

The next two pictures show the ewe between 10:40 a. m. and 11:35 a. m. She is now down and unable to arise. Drowsiness is much advanced. Respiration is slow, and breathing takes place through the open mouth. There is a feeling of indisposition, as indicated by a grating of the teeth and a shifting of the head back and forth.

In the next to the last picture in the series the ewe is on her side in a very weakened drowsy condition. Now and then the head is held up for a minute or so, then it falls back. At this stage of poisoning there is a slight shifting of the body into either a normal lying down position or one lying flat with legs and head outstretched. This picture shows the ewe a few minutes before death. All bodily action is gradually ceasing. The pulse is weak, and the breathing can hardly be detected. It is impossible to arouse her, she is in a state of profound insensibility.

The final picture shows the animal immediately after death, which occurred quietly and without a struggle. The bloating is characteristic.

FEEDING GREASEWOOD WITH A MIXTURE OF GRASSES AND WEEDS

The purpose of this feeding test was to imitate more closely the actual range feeding conditions; and thus to determine the effect

of a daily ration composed of greasewood with grasses, clovers, and weeds.

For this test two ewes were selected, weighing 89 and 90 pounds, respectively. For five days they were fed only green grasses, clovers, and weeds. This initial feeding period was to determine their average daily consumption for this type of ration. It was found to be 8.91 pounds per day per ewe. This is about the number of pounds of green forage that they would eat if they were grazing naturally on this class of feed on the range. The grass-clover-weed mixture consisted of blue grass, orchard grass, white clover, alfilaria, sow thistle (*Sonchus*), dandelions, and wild lettuce (*Latuca*).

The grass-clover-weed mixture was then reduced in amount by 4 per cent of the live weight of each of the ewes. Now, instead of each ewe being fed 8.91 pounds, this quantity was lowered to 5.33 pounds of the grass-weed mixture with 3.58 pounds of greasewood added. The two ewes were now fed for seven complete days on this ration. At no time during this period did this ration cause any injurious effect that could be attributed to the greasewood.

At the completion of this seven day period the amount of grasses and weeds being fed was again reduced by one per cent of the live weight of the ewes. The ewes were now eating in greasewood leaves an amount equivalent to five per cent of their live weight. The ration now was made up of 4.27 pounds of greasewood leaves mixed with 4.64 pounds of the grass-clover-weed mixture. This 8.91 pound ration was fed for fourteen days. Again no injurious effect could be detected.

This was especially interesting because of the fact that poisoning had developed in previous feedings when the greasewood leaves had been fed as the sole ration and at one feeding in an amount equivalent to 5 per cent of the live weight of the animal.

Because no poisoning symptoms developed during the period of 21 days in which the ewes were daily eating greasewood leaves in the amount equivalent to 4 and 5 per cent of their body weights, it can be quite safely stated that greasewood is not poisonous when eaten with other forage in ordinary amounts. Further, in view of the rather large amount of greasewood leaves that these two ewes actually consumed without causing symptoms of poisoning, it may not be wrong to say that under normal range conditions the greasewood is an important source of range forage.

FEEDING GREASEWOOD LEAVES AT DEFINITE INTERVALS

The two previous and distinct series of feeding tests showed that, (1) when rather large amounts were fed at one feeding symptoms of poisoning developed, and (2) when correspondingly large quantities of greasewood leaves were fed with other green forage and the sheep were allowed to eat this mixture during the course of a day no symptoms could be detected. It now seemed desirable to feed at intervals small quantities of greasewood leaves alone to determine what amount could be eaten under such feeding conditions without causing harmful results.

The following table gives the results of this series of feeding tests:

GREASEWOOD LEAVES FED AT DEFINITE INTERVALS

Animal number	Time fed	Date fed	Weight of animal, lbs.	Amount fed lbs.	ozs.	Severity of poisoning	Ozs. fed per 100 lbs. live weight	Per cent fed of live weight	Lbs. fed per 100 lbs. live weight
1790	10:00 a. m.	7-29-25	100	2	8	Negative	40.0	.025	2.5
1790	2:30 p. m.	7-29-25	100	2	8	Negative	40.0	.025	2.5
46	9:00 a. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	10:00 a. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	11:00 a. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	12 (noon)	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	1:00 p. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	2:00 p. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	3:00 p. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	4:00 p. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
46	5:00 p. m.	5-28-26	142	1	0	Negative	11.2	.007	0.7
1800	8:00 a. m.	5-20-26	102	2	0	Negative	31.3	.0196	1.96
1800	11:00 a. m.	5-20-26	102	2	0	Negative	31.3	.0196	1.96
1800	2:00 p. m.	5-20-26	102	2	0	Negative	31.3	.0196	1.96
1233	8:00 a. m.	8- 7-26	90	2	0	Negative	35.5	.0223	2.23
1233	12 (noon)	8- 7-26	90	2	0	Negative	35.5	.0223	2.23
1233	4:00 p. m.	8- 7-26	90	2	0	Negative	35.5	.0223	2.23

The above table shows that four series of feedings were made. In each series 5 per cent or more of the animal's weight was fed in the form of greasewood leaves. In previous feedings greasewood leaves fed at one time in an amount equalling or exceeding 5 per cent of the live weight of the animal generally produced poisoning symptoms with recovery or death.

In the first series sheep 1790 was fed twice, once in the morning and once in the afternoon. A period of about four hours elapsed between feedings. In each feeding 2½ per cent of the sheep's live weight was fed in greasewood leaves. The total of the two feedings was 5 per cent, but the result of the test was negative.

In the second series sheep number 46 was fed hourly nine times between 9 a. m. and 5 p. m. Each feeding was in the amount of one pound. The total amount of greasewood leaves fed represents approximately 6.3 per cent of the live weight of the sheep. The nine pounds fed during the period of nine hours failed to produce symptoms of poisoning. These nine pounds are probably a greater amount of greasewood leaves than a sheep of this weight would ordinarily eat during the grazing period of a day on the range. This test further emphasizes the important fact that poisoning from greasewood leaves comes from eating an amount approximating the stomach capacity in a relatively short period of time.

In the third series sheep No. 1800 was fed three times. At each feeding two pounds were fed. The feedings were made at three-hour intervals. In all six pounds were fed, this amount representing 5.88 per cent of the sheep's live weight. No symptoms of poisoning could be detected at any time during the period of observation which extended to 5 p. m. the following day.

In the fourth series sheep No. 1233 was fed three times. Four hours elapsed between the feedings. In all, six pounds were fed and this amount was 6.69 per cent of the sheep's live weight. No symptoms of poisoning were detected at any time during the 34 hours that the sheep was under observation. The sheep used in this test weighed 90 pounds. A fair estimate of the amount this sheep would eat in range forage during the period of a day would be about nine pounds. In this test six pounds of greasewood leaves were fed, a quantity which is about 66 per cent of the total amount of forage that a sheep of this size would

consume in green forage during the daylight or feeding hours on the range.

DAILY FEEDING TESTS TO DETERMINE THE INJURIOUS EFFECTS OF GREASEWOOD LEAVES

The following table gives the results of daily feedings of definite amounts of greasewood leaves mixed with grasses and clovers to determine whether there are any injurious cumulative effects as shown by a loss of weight:

Animal number	Date fed	Time fed	Amount fed lbs.	Amount fed ozs.	Weight of animal, lbs.	Ozs. fed per 100 lbs. live weight	Per cent fed of live weight	Lbs. fed per 100 lbs. live weight
146	5-19-26	4:10 p. m.	2	8	142	28.1	.0176	1.76
146	5-20-26	9:50 a. m.	2	8	142	28.1	.0176	1.76
146	5-21-26	9:15 a. m.	2	8	142	28.1	.0176	1.76
146	5-22-26	9:15 a. m.	2	8	142	28.1	.0176	1.76
146	5-23-26	9:00 a. m.	2	8	142	28.1	.0176	1.76
146	5-24-26	1:30 p. m.	2	8	142	28.1	.0176	1.76
146	5-25-26	8:00 a. m.	2	8	142	28.1	.0176	1.76
146	5-26-26	8:10 a. m.	2	8	142	28.1	.0176	1.76
146	5-27-26	9:30 a. m.	2	8	142	28.1	.0176	1.76
146	5-28-26	9:05 a. m.	2	8	142	28.1	.0176	1.76
146	5-29-26	10:40 a. m.	2	8	142	28.1	.0176	1.76
146	5-30-26	9:00 a. m.	2	8	142	28.1	.0176	1.76
146	5-31-26	9:10 a. m.	2	8	142	28.1	.0176	1.76
146	6- 1-26	9:25 a. m.	2	8	142	28.1	.0176	1.76
146	6- 2-26	9:05 a. m.	2	8	141.75	28.2	.0176	1.76
123	8- 1-24	9:00 a. m.	4	0	98	65.3	.0408	4.08
123	8- 2-24	9:40 a. m.	4	0	98	65.3	.0408	4.08
123	8- 3-24	10:55 a. m.	4	0	98	65.3	.0408	4.08
123	8- 4-24	8:30 a. m.	4	0	98	65.3	.0408	4.08
123	8- 5-24	9:00 a. m.	4	0	98	65.3	.0408	4.08
123	8- 6-24	10:10 a. m.	4	0	98	65.3	.0408	4.08
123	8- 7-24	8:00 a. m.	4	0	98	65.3	.0408	4.08
123	8- 8-24	7:45 a. m.	4	0	98	65.3	.0408	4.08
123	8- 9-24	11:45 a. m.	4	0	98	65.3	.0408	4.08
123	8-10-24	9:05 a. m.	4	0	95.50	67.0	.0418	4.18

The following facts are shown by the above table:

(1) Sheep No. 146 was fed daily 2½ pounds of greasewood leaves for the period May 19 to June 2, inclusive. During this 15 day interval 37½ pounds of greasewood leaves were consumed. There was a loss of one-fourth pound in the live weight of the sheep. This amount is too small to be attributed to any cause.

(2) Sheep No. 123 for a period of 10 days was fed daily four pounds of the greasewood leaves. The total amount of greasewood leaves eaten was 40 pounds.

There was a loss of 2½ pounds in the weight of the sheep. This decrease in live weight cannot be definitely assigned to the presence of the greasewood leaves in the ration for, during the time that this test was being made, there was a tendency on the part of the sheep to select the grasses and clovers first, leaving after each feeding a varying amount of greasewood leaves not eaten. This necessitated forced feeding of the remaining greasewood leaves. Consequently there was much daily handling of the sheep which could account for the loss of weight.

At no time during the time that these two tests were in progress nor afterwards did any visible injurious effect develop. This series of feedings again further emphasizes the statement that sheep become poisoned by greasewood leaves as a result of eating the leaves and green stems almost exclusively in a quantity approximating the stomach capacity during a relatively short time.

LENGTH OF TIME FOR THE APPEARANCE OF SYMPTOMS OF POISONING

The period of time that elapses before the characteristic symptoms appear after the ingestion of either a toxic or a fatal quantity of greasewood varies with different sheep according to the amount of leaves eaten in excess of the amount necessary to cause poisoning.

It required as an average about three hours and twenty-five minutes for the first visible symptoms to develop after the animal was fed a toxic or a fatal amount. In a few of the experimental sheep the symptoms appeared in less than two hours; but for most of the sheep that came under observation the interval before the appearance of symptoms was between three and five hours. The time that elapsed between the detection of the first symptoms and the death of the animal varied greatly, it being from twelve to over twenty hours.

SYMPTOMS OF POISONING

The symptoms of fatal poisoning arising from the eating of greasewood leaves are few and not distinctive. There is an initial period of drowsiness during which the sheep stands or walks in a listless stupid condition. This period of dullness gradually develops into a weakness which compels the sheep to lie down. Gradually the depression becomes more pronounced, the pulse weakens, and a state of profound prostration with partial unconsciousness develops. In this condition life may continue for several hours before the heart finally ceases to function and death comes.

AUTOPSY FINDINGS

Several of the sheep which were killed in these tests were autopsied and nothing abnormal was observed which could be attributed to the poisonous action of this plant.

PRACTICAL SUGGESTIONS FOR AVOIDING GREASEWOOD POISONING

The experimental feeding tests with the conclusions drawn from them clearly show that the greasewood may be listed as a poisonous plant only under certain special feeding conditions. The following explanation makes clear when sheep losses may be expected as a result of browsing upon the greasewood.

This shrub, during the winter months, is leafless and spiny. In the early spring it produces young tender stems and leaves. This juicy new growth is easily browsed by sheep. Later on during the summer and fall the new spring growth becomes somewhat dry, spiny, and unpalatable. Therefore most of the browsing on the greasewood by sheep occurs during the period when its leaves and stems are tender and palatable. There is, however, considerable eating of the greasewood leaves during the fall months after the leaves have fallen to the ground, but apparently the leaves cause little trouble at this season of the year.

During the period when the early spring growth is most appetizing and easily browsed, losses may be expected; but only when hungry sheep, especially those that are salt hungry, are permitted to fill up quickly and almost exclusively on the greasewood.

The greasewood has a somewhat salty taste, which makes it particularly relished by salt hungry sheep. It has been reported by some sheepmen that salting the sheep is a valuable precautionary measure when changing the flock from a range free from greasewood to one where it is growing abundantly.

Trailing sheep from one feeding ground to another often requires going over grazing ranges on which there is little or no feed, and frequently salting is delayed until the new feeding grounds are reached. A trailing flock of forage hungry, salt hungry sheep coming upon a greasewood area are in great danger. The same may be said of sheep held in shearing corrals and penned for varying periods of time and then allowed to graze in an extremely hungry condition upon areas supporting the greasewood.

Under normal range and feeding conditions the greasewood is a safe plant for sheep to browse, but if hungry sheep are permitted to satisfy their hunger quickly and completely on it then poisoning and death may be expected.

PART II (Technical)
CHEMICAL STUDIES OF GREASEWOOD

THE CHEMICAL EXAMINATION OF GREASEWOOD

A proximate analysis of a browse plant may not fully indicate its feeding value or show all of its properties. Such an analysis is reported by Forbes and Skinner[1] for *Sarcobatus vermiculatus*, and is given as follows:

Moisture	4.55%
Ash	14.41%
Ether Extract	2.45%
Crude Protein	19.81%
N-free Extract	34.28%

These authors state that "the plant is of surprisingly nutritious character as indicated by the analysis, being rich in protein, fat, and carbohydrates." The figures quoted give no ground for the rejection of the plant for grazing purposes; yet, under actual feeding conditions, the greasewood fails to fulfill the promise given by its analysis.

The plant is extensively grazed by sheep, and there are records of its toxic action in these animals. Its poisonous character has been fully demonstrated in the feeding trials here reported, and also by Marsh, Clawson and Marsh.[2]

As in the case of some other browse plants which are poisonous when fed under certain experimental conditions, it surely would seem that under other conditions, in spite of its high oxalic acid content, the greasewood should be credited with some degree of usefulness in the ration on the range.

To the varying proportion of greasewood in the range ration and to the physiological condition of the sheep the variation in symptoms must be ascribed. It is evident that not all sheep are poisoned while on a range which supports *Sarcobatus vermiculatus*. Were this so the plant would unquestionably be characterized as highly poisonous. Consequently, the proportion which it forms of the ration must be one of the important factors of danger in its presence.

If the greasewood constitutes the sole source of feed in a given area it may very conceivably lead to mass poisoning of the animals in the area. On the other hand, if greasewood were found only occasionally, with the other plants in abundance, its poisonous properties would not be noticed and no suspicion would attach to it. If a poisonous plant does not have habit forming properties, such as have been found with certain loco plants, its actual presence in a mixed browse ration may not be observed; and its feeding value in the ration may never be questioned.

Another important factor with plants of this character which may be described as being on the borderline of usefulness, is the physiological condition of the animals concerned. Under conditions in which, for

[1]Forbes and Skinner. Arizona Station Report, 1903.
[2]Marsh, Clawson and Marsh, U. S. D. A., Circular 279.

example, there is a lack of necessary salts, animals having access to plants which may be palatable on account of their salty taste, may eat such plants to excess and to the exclusion of other more nutritious forms. A condition may occur in which greasewood helps to satisfy the craving for salt. As a consequence some of the animals eat it to excess and the harmful effects of some of its constituents soon become evident. Greasewood is probably not the only plant of this character. A consideration of the properties of some of the salt bushes might lead to the same conclusions. Succulence may, in the same manner, serve to make a plant more attractive under conditions of a lack of drinking water or a scarcity of succulent feeds.

There can be but little doubt that the poisonous character of the plant is due to the presence of salts of oxalic acid. This has been reported by the above authors and also by Couch,[3] who conclude that greasewood poisoning is due to a mixture of the sodium and potassium salts of oxalic acid. The presence of soluble oxalates may be demonstrated easily by the usual means employed for their detection.

The quantitive estimation of the oxalates, however, presents greater difficulties than their simple detection. These involve (1) the complete extraction of the oxalates present, and (2) their precipitation and removal in a form suitable for their estimation. Filtration is made difficult by the presence of colloidal and colored extractives; and the precipitation and removal of calcium oxalate in a pure state is hindered.

Couch (10c. cit.) reported results of determinations of oxalates on material from Utah, which were obtained by a method of analysis devised for the purpose. These are given as follows:

	Dried leaves per cent	Stems per cent	Leaves, stems, fruit per cent
Moisture	5.50	5.82	8.64
Water-soluble oxalic acid, anhydrous	10.47	2.35	9.40
Total oxalic acid, anhydrous	12.20	4.37	11.54

These results calculated to a moisture-free basis for comparison with the figures in the following table are equivalent to:

	Dried leaves per cent	Stems per cent	Leaves, stems, fruit per cent
Moisture	0.00	0.00	0.00
Water-soluble oxalic acid, anhydrous	11.07	2.49	10.28
Total oxalic acid, anhydrous	12.91	4.64	12.63

On samples from the vicinity of Reno the percentages were found in general to be higher than those reported above. The samples were collected through the year on the dates indicated. Total oxalic acid, anhydrous only, is reported and calculated both to moisture-free condition and as in the original green plant:

[3]Couch, Amer. Jour. Pharm., 94 (1922), 631–641.

OXALIC ACID CONTENT OF LEAVES OF SARCOBATUS VERMICULATUS

Number	Date collected 1926	Total moisture per cent	Anhydrous Oxalic Acid	
			Original per cent	Moisture-free per cent
846	May 29	76.80	2.64	11.40
857	June 19	70.51	4.10	13.92
860	July 17	69.58	3.73	12.29
867	Aug. 7	69.52	4.03	13.23
877	Sept. 4	68.23	4.89	15.39
885	Sept. 25	69.80	4.11	13.63

The seasonal variation in the total content of oxalic acid is clearly shown in the preceding table. By this it may be seen that when the leaves are young in the spring the oxalic acid content is at its lowest level. It increases as the season progresses until autumn when it begins to decline. This decrease may be due to leaching out by rain at that time of year or it may be due to a partial removal by the plant itself through conversion into other compounds.

The method used for the determination of oxalic acid differed from that of Couch in that the total amount of oxalates was determined by extraction with a solution of hydrochloric acid. By this procedure the oxalic acid of the soluble salts and that occurring combined with calcium is liberated in the same extract.

Extraction was accomplished on the water-bath by the aid of mechanical stirring, and the extract was separated by filtration and washing with hot water by suction, using filter paper on a Buchner funnel.

In this method it is probable that a greater degree of dilution was attained than that used by Couch. It was found that at higher dilutions the difficulties of filtration of the extract and the removal of precipitated calcium oxalate were greatly reduced. The extract was now evaporated to near dryness to eliminate colloidal material which hinders filtration on account of excessive amounts of coloring matter which seemed to form through oxidation or decomposition. It was found that a cleaner precipitate could be obtained by precipitating after evaporation. In our determinations, however, the filtered and washed precipitate was taken up with hot dilute sulfuric acid and the oxalic acid titrated with standard permanganate solution. This procedure may give slightly higher results than ignition of the precipitate on account of absorption of the colloidal material by the finely divided precipitate.

Extractions were made of the plant under acid and alkaline conditions to determine the presence of alkaloids. Nothing was found which would give a reaction with the commonly used alkaloidal reagents.

The foaming properties of aqueous extracts of the plant indicated the possibility of the presence of saponins. To test for the presence of hemolytically active saponins an extract of the air-dried leaves was made with physiological salt solution. Dilutions were made with this extract ranging in concentration from 1 part of dried plant in 50 of extract to 1 part in 500. A suspension of washed corpuscles of sheep's

blood was prepared with salt solution. One hundred cc. of this suspension contained the corpuscles of 1 cc. of definbrinated blood. Equal parts of the different solutions of the extracts and suspension of corpuscles were mixed but no hemolysis was observed to take place.

The test outlined only serves for the detection of those saponins which are capable of breaking up red corpuscles. While it must be conceded that the presence of inactive saponins is not disclosed by this test, in general the toxic saponins are hemolytically active, hence from these results it was concluded that toxic saponins were absent.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 116 RENO, NEVADA June, 1929

SIMPLIFIED METHODS *of* CALCULATING DAIRY RATIONS

In this bulletin is presented a discussion of popular methods of feeding dairy cows and a statement of the principles upon which profitable feeding is based. Charts are provided which greatly simplify the calculation of balanced rations.

By
F. B. HEADLEY
Chief, Department of Farm Development

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

Printed at the
STATE PRINTING OFFICE : : : JOE FARNSWORTH, SUPERINTENDENT
CARSON CITY, NEVADA

1[54]

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

OFFICERS

STAFF

SUMMARY

1. More efficient methods are needed in the feeding of dairy cows that will result in lowering the cost of production, or in increasing the output without increasing the cost in like proportion.

2. A brief discussion is given showing the relation between the nutrients in dairy feeds to the amount of food necessary to maintain the body weight and to supply the nutrients essential to the transformation of the food into milk.

3. Five common methods of rationing dairy cows are discussed so as to point out the faults and desirable features of each. An all-alfalfa ration without grain supplements is the most economical for cows of low productive capacity. Grain supplements should be fed to cows giving more than 300 pounds of butter fat per year but the amount of grain fed should be based on the needs of the individual cows.

4. An easy method is presented of determining the nutritive requirements of each individual cow and of finding the amount of hay and grain necessary to meet these requirements.

5. An easy method is given for determining, by means of calculating charts, the total digestible nutrients and the digestible protein in various combinations of the more common dairy feeds used in Nevada.

6. Charts are provided by means of which the cost per pound of total digestible nutrients and of digestible protein in the dairy feeds common in Nevada can be quickly determined at any market price.

SIMPLIFIED METHODS OF CALCULATING DAIRY RATIONS

INTRODUCTION

During the past decade there has been such a narrow margin between the cost of producing farm products and the amount received for them that thousands of farmers have each year been forced out of the farming business. It is probable that there has been a survival of the fittest so that those now left are to some extent a selected group who conduct their farms by relatively efficient methods.

Just as industrial concerns have learned that their continued existence depends upon the adoption by them of the most efficient and economical methods of production, so may farmers learn to profit by the adoption of new methods that will cut their costs of production. In this bulletin is presented a discussion of different methods of feeding dairy cows, and a method of rationing is recommended which, it is believed, will result in lower costs of producing milk and butter fat.

PRINCIPLES OF FEEDING DAIRY COWS

Cows eat grass, hay and grain to obtain the necessary nutrients for the maintenance of their bodies and the production of the milk they produce. Not all the food they eat is digested. A part of it is indigestible and is eliminated from the body as waste. The part that is digestible is termed "digestible nutrients" and it is the digestible nutrients in feeds that are most valuable to dairymen.

DIGESTIBILITY OF FEEDS

Not all feeds are equally digestible. The digestibility of alfalfa hay is 51.6 per cent, bran 60.9 per cent, and corn 84.2 per cent. Each food product has a digestion factor that has been found in most cases by actual feeding trials with animals. Foods like corn and barley that have a high digestibility are called "concentrates" and those with a low digestibility like hay and silage are called "roughages."

MAINTENANCE REQUIREMENTS OF COWS

Cows require a certain amount of food to maintain their body weight and to provide for the growth of the unborn calf. The amount required for maintenance has been found by experiment to be roughly proportional to the weight of the cow. The factor most usually adopted by dairy specialists as being the amount required for daily maintenance of the average dairy cow is 7.925 pounds of digestible nutrients per 1,000 pounds live weight. For all practical purposes the dairyman may adopt eight pounds digestible nutrients per 1,000 pounds live weight as his standard. In terms of alfalfa hay, this is equivalent to 15.4 pounds for a cow weighing 1,000 pounds or 20 pounds hay for a cow weighing 1,300 pounds. This amount of hay is an overhead expense. It is only the food which the cow eats in excess of this maintenance ration that goes into the production of milk.

REQUIREMENTS FOR MILK PRODUCTION

The food that the cow eats in excess of that required for maintenance goes either into the production of milk or the laying on of fat in the body. Good dairy cows use their excess food for milk production and are very difficult to fatten, but there are cows that cannot be forced into high milk production because they do not have the inherent ability of the typical dairy cows to turn their food into milk.

It has been found by thousands of trials conducted by dairy specialists in different parts of the world that the amount of digestible nutrients required by good dairy cows for the production of milk is quite constant for milk of any given fat content, but more nutrients are required for milk rich in fat than for milk of poorer quality. For instance, each pound of milk testing 3.5 per cent requires that the average cow should eat .295 pound of digestible nutrients in excess of the nutrients required for maintenance. In terms of alfalfa hay this means .6 pound of hay must be eaten for each pound of milk produced. The production of 40 pounds of milk by a 1,300 pound cow would then require:

20 pounds hay for maintenance
24 pounds hay for the milk
—
44 pounds hay total

The consumption of 44 pounds of hay per day is beyond the capacity of most cows. However, some cows are able to produce more than 40 pounds of milk daily on an all-hay ration for several months by utilizing the fat of the body that was accumulated during the time of low production near the end of the previous lactation period and while dry. There is also a difference in the efficiency of animals in digesting their foods which may account for the ability of some unusual cows to produce more than would be expected of them on an all-alfalfa hay ration.

The capacity of the average cow to consume hay is limited to about 30 pounds per day for a 1,000 pound cow or 36 pounds for a 1,300 pound cow. To get an amount of milk during the year greater than can be supplied by the hay the cow is capable of eating requires an additional ration of concentrates.

PROTEIN

The digestible nutrients discussed above contain the nutritive elements protein, carbohydrates and fat. In Nevada where alfalfa or other legume hay is almost universally fed as roughage it is not often necessary to take the amount of protein into consideration, but when legume hay is not available with which to feed the dairy herd it will be necessary to add protein to the ration by feeding protein-rich concentrates as will be explained later.

With these explanations the dairyman will be able to more fully understand the faults and virtues of the feeding methods to be described.

DAIRY COW RATIONS

One of the factors in securing economical production of dairy products consists in the giving of careful attention to the dairy ration in order that the cows may be fed the amount of nutrients required

for the most efficient and economical production. In actual practice there is little unanimity among dairymen as to what constitutes efficient and economical feeding. In practice there are five well defined methods of rationing dairy cows.

THE ALL-ROUGHAGE RATION

1. The most common practice in Nevada is to feed all the alfalfa hay the cows will eat without any grain supplement. There is no question but that this method of feeding results in remarkably high production when the cows receive alfalfa hay of good quality. Individual cows fed on alfalfa hay alone have been known to produce over 400 pounds of butter fat in one year while cows producing in excess of 300 pounds of butter fat without any other feed than alfalfa hay are quite common. However, when there are cows in the herd of high productive capacity, greater production and larger net returns can be obtained under normal price conditions if grain were to be fed according to the requirements of the individual cows.

A cow fed on roughage alone is limited in the amount of milk and butter fat she can produce. The digestive capacity of cows is limited. Cows of high productive capacity cannot eat and digest enough food in the form of roughage to supply the nutrients required for heavy milk production. It is, therefore, profitable to feed grain supplements to heavy producers but it is not profitable to feed grain to mediocre cows whose production is not in excess of the nutrient requirements that can be met by the all-hay ration. For these reasons the all-hay ration is the most profitable for cows of low or average productive capacity, but a grain supplement becomes profitable when fed to cows of high productive capacity. It is poor business to underfeed good cows.

THE SHARE-ALIKE GRAIN RATION

2. Where grain is fed it is a very common practice to feed practically equal grain rations to all cows. This method of feeding is faulty because of the waste that is certain to occur since the cows are not fed according to their individual requirements. The low producing cows are getting grain that they do not need, thereby increasing the cost of production. The better cows of the herd, on the other hand, may not be getting sufficient grain to make possible the highest economic production, and the owner is losing an opportunity to increase his net income. Alfalfa hay provides the cheapest form of total digestible nutrients. Costly concentrates should not be fed when the cow is able to supply her nutrient requirements with alfalfa hay alone. It is bad business to overfeed poor cows. On the other hand, when a high producing cow is not capable of eating sufficient alfalfa hay to supply her nutrient requirements she should be fed sufficient grain to provide these nutrients, especially when one pound of butter fat is worth twenty or more pounds of grain.

THE GRAIN-MILK RATIO METHOD

3. There is a method of rationing cows that is very commonly advocated by experiment station and extension workers, and that is to feed grain in proportion to the amount of milk produced. The ratios of

grain to milk most commonly advised varies from one pound of grain to three pounds of milk for the lighter breeds, to one pound of grain to five or six pounds of milk for the heavier breeds.

This is a more logical procedure than the feeding of equal grain rations to all cows, since the cows are fed in proportion to their milk production. This method has been widely advocated because of the ease with which it can be applied in practice and because it approaches the balanced ration in efficiency. It results, however, in overfeeding poor cows since all cows get some grain. Sufficient nutrients are provided by alfalfa hay alone for low producing cows. It is a waste of money to feed high priced concentrates to supply digestible nutrients that can be provided by alfalfa hay. The digestible nutrients in hay worth $12 per ton cost only 1.2 cents per pound while digestible nutrients in barley at $1.75 per cwt. costs 2.2 cents per pound. It is economy in this case to feed the cheaper form of digestible nutrients up to the point where the capacity of the cow is reached when additional nutrients must be provided in the more costly concentrate form. This ratio method of feeding could be improved by altering it to read as follows: Feed Holsteins one pound of grain to every 2½ pounds of milk they give in excess of 30 pounds and feed Jerseys one pound grain to every 2 pounds of milk they give in excess of 25 pounds. When thus modified, the low producers would not be overfed.

THE GRAIN-FAT RATIO METHOD

4. A plan that has been advocated to some extent but which has not been widely adopted is to feed as many pounds of grain to each cow per day as she produces butter fat in a week. The calculation required would be to multiply the daily yield of milk in pounds by seven and by the per cent fat. The result would be the number of pounds of butter fat produced per week, which corresponds with the number of pounds of grain to feed per day. The method is not popular probably because of the calculations required, and it would not result in a wholly satisfactory ration.

THE BALANCED RATION METHOD

5. The method of feeding most widely advocated by experiment stations is to provide a balanced ration designed to meet the requirements of each individual cow. The requirements for dairy cows have been worked out experimentally by dairy scientists in various parts of the world. The results are in quite general agreement and indicate that the most economical results can be obtained by balancing the rations.

It has, however, been so difficult to calculate balanced rations that most practical dairymen shy away from this method. Even graduates of agricultural colleges who have been trained in making these calculations frequently abandon this for one of the easier methods. It is only because of the difficulty in making the calculations that this method has not been more generally adopted.

By a balanced ration is meant the feeding of just enough digestible nutrients, both of protein and carbohydrates, to supply the requirements of the cow in maintaining her body weight and in manufacturing the milk and butter fat she produces. The amount of wastage is reduced to a minimum. Each cow is fed to the limit of her capacity to

produce economically. Good cows are fed enough to bring the greatest economic returns, while on the other hand, expensive concentrates are not wasted on poor cows that do not respond to feeding.

If it were not for the difficulty of making the calculations, most progressive dairymen would undoubtedly adopt the balanced ration system of feeding. To make calculations easier the author has worked out calculating charts that are easy to use and which make it possible to calculate in a very short time the nutrient requirements of any individual dairy cow and the amount of each kind of feed necessary to meet those requirements. The charts are simple, so that any farmer may quickly learn to use them.

It is necessary to know or to estimate the daily production of milk, the average per cent butter fat, and the approximate weight of the cow. The rations should be readjusted once or twice a month. An estimated weight of the cow will be sufficiently accurate on most private farms. An approximate butter fat percentage may be used if monthly tests are not made. When the tests of the individual cows of the herd are not known the average percentage for the breed may be used as follows:

Ayrshire	4.0%
Brown Swiss	4.0%
Guernsey	5.0%
Jersey	5.4%
Holstein	3.4%

CALCULATING GRAIN RATION BY CHART

Chart I is designed for the purpose of calculating the nutrient requirements of dairy cows and the amount of grain and hay necessary to meet these requirements. Take for example:

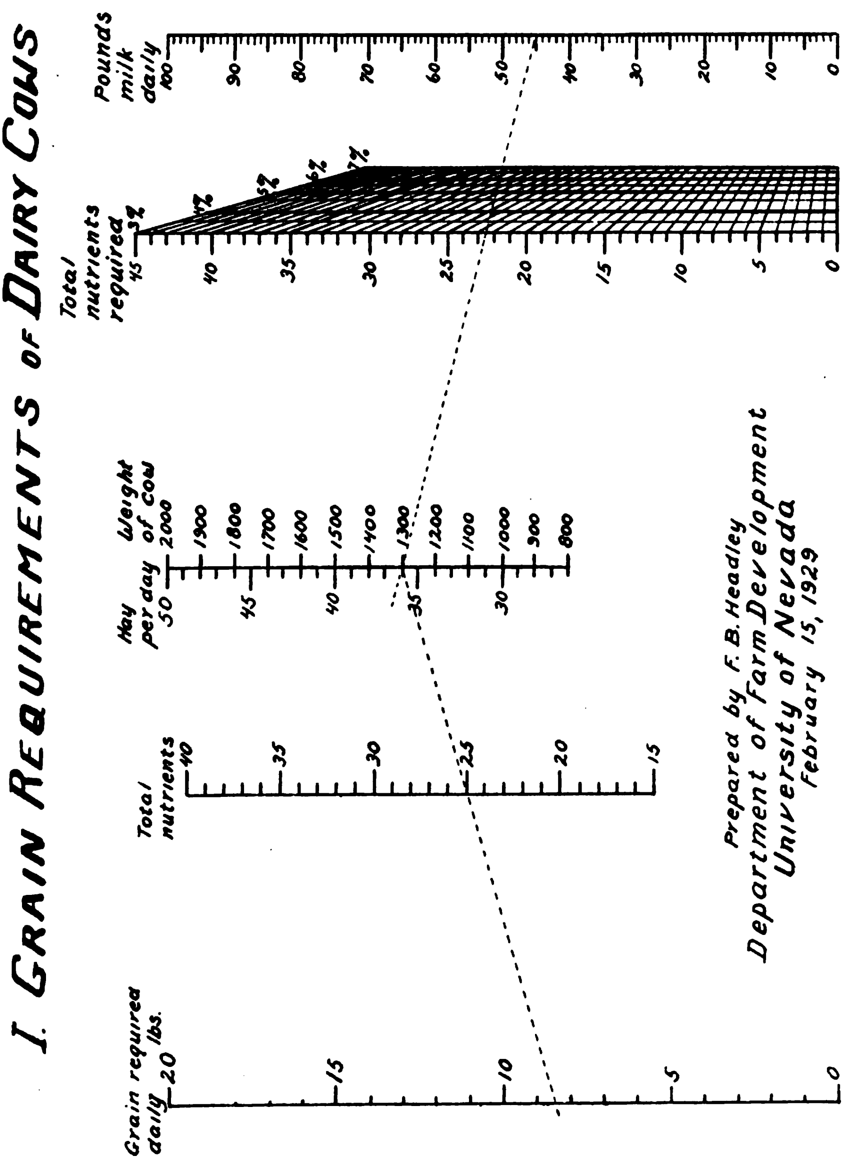
Weight of cow..	1,300 lbs.
Milk per day..	45 lbs.
Test..	4%

How much grain in addition to normal hay consumption should be fed to meet requirements?

1. Lay a ruler from 45 on the *right-hand scale* to 1,300 on the *weight of cow* scale in the center of the chart. Place the point of a pencil where the ruler crosses the *4% line in the series of middle scales.* Remove the ruler, leaving the point of the pencil in place and read the result on the scale, which is 25.0 pounds.

2. Replace the ruler so that it will cross 25.0 on the *pounds total nutrients scale* on the left half of the chart and *1,300 pounds weight of cow on the same scale as before* and note the reading where the ruler crosses the *left-hand scale,* "pounds grain required daily," which is in this case, 8.4 pounds. This means that 8.4 pounds of grain mixture is required in addition to normal consumption of alfalfa hay to supply nutrient requirements.

In like manner, the grain requirements may be determined for cows of any other weight and productive capacity, thereby avoiding the use of tables and complicated arithmetical computations.


I. GRAIN REQUIREMENTS OF DAIRY COWS
Grain required daily lbs.
20
15
10
5
0
Total nutrients
40
35
30
25
20
15
Hay per day
50
45
40
35
30
Weight of cow
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
Total nutrients required
45
40
35
30
25
20
15
10
5
0
3%
4%
5%
6%
7%
Pounds milk daily
100
90
80
70
60
50
40
30
20
10
0
Prepared by F. B. Headley
Department of Farm Development
University of Nevada
February 15, 1929

HAY CONSUMPTION OF COWS

In a general way cows are able to consume an amount of hay roughly proportionate to their weight, as indicated by the central scale of Chart I, but the appetites of individual cows of equal weight may differ quite materially. These charts are constructed for average cows. If the dairyman is sure that any of the cows in his herd eat a different amount of hay than that shown for given body weights, he may use the hay scale instead of the weight scale when calculating the grain required.

If, in the example given above, the dairyman were to assume that the 1,300 pound cow eats 38 pounds of hay daily, he may place the ruler from 38 on the hay scale to 25.0 on the nutrients scale and will then note that only seven pounds of grain are required instead of 8.4 pounds that were found to be required if she consumed the smaller amount of hay daily.

If the farmer has wild or timothy hay without alfalfa it is not probable that his cows will be able to eat so much as is indicated by the chart. A cow weighing 1,300 pounds receiving nonlegume hay might eat only 30 pounds per day. In such a case, lay the ruler from 30 on the hay scale to 25 on the nutrients scale and it will be found that 12.5 pounds of grain will be required.

When cows are on pasture they will usually require the same grain ration as when they are on a full feed of alfalfa hay. Pasture grass is a roughage, and high producing cows are unable to eat and digest enough to supply nutrients for all the milk they are capable of producing economically. For this reason grain should be fed to high producing cows on pasture.

KIND OF GRAIN

For all practical feeding where alfalfa hay constitutes the greater part of the roughage fed, Chart I is sufficiently accurate to be used without correction, regardless of the kind of grain. If it were necessary to take the protein into consideration this would not be the case, but in all available rations protein is supplied in excess when alfalfa hay is fed. The total nutrients in any ration that is likely to be compounded from the feeds available in Nevada will fall within the limits of the standard ration as suggested by Henry and Morrison.

Calculating from tables in Feeds and Feeding, it will be found that the requirements for a cow weighing 1,300 pounds and giving 45 pounds of 4% milk are as follows:

	Digestible Nutrients Required — Minimum	Maximum
Maintenance (factor .07925)	10.30 lbs.	10.30 lbs.
Milk (factors .311–.346)	14.00 lbs.	15.57 lbs.
Total nutrient requirement	24.30 lbs.	25.87 lbs.

It appears from this that the nutrient requirement may be taken at any point between these two figures, 24.3 and 25.9. The chart indicates that 8.4 pounds of grain in addition to 36 pounds of alfalfa hay will meet these requirements. Eight and four-tenths pounds of any grain mixture that is likely to be compounded from the most commonly used feeds, viz.: Barley, oats, corn, millrun, linseed or cottonseed oil

meal will supply total nutrients between the limits 24.3 and 25.9 required by the standard.

Whenever alfalfa hay or other legume is not available it will be necessary to add some concentrate, rich in protein, to the ration. Cottonseed meal or linseed meal are suitable for this purpose. Oil meal may be added to other concentrates in the proportion of one part oil meal to 2 or 3 parts of barley, corn, millrun or other low protein feed. Oil meal need not be included in the grain ration so long as alfalfa hay constitutes as much as 50 per cent of the roughage.

TOTAL NUTRIENTS IN VARIOUS FEED COMBINATIONS

While Chart I will be found sufficiently accurate for practical farm use, it is sometimes desirable to be able to determine the amount of total digestible nutrients in any combination of available feeds. This will be especially the case when agricultural classes in high schools and colleges are studying the subject of dairy rations.

For this purpose Chart II is presented. By its use the total digestible nutrients in any combination of the commonly used dairy feeds of Nevada may be quickly calculated. The inclusion of other roughages than alfalfa has been purposely avoided in order to keep the chart as simple as possible. The substitution of bluegrass or timothy hay for alfalfa will not materially affect the results, since bluegrass contains the same percentage of digestible nutrients as alfalfa and timothy hay contains only .6 per cent less nutrients.

If silage is fed it will be sufficiently accurate to assume that one pound of alfalfa is equivalent to three pounds corn silage or four pounds sunflower silage. Assume, for example, that 25 pounds alfalfa hay is fed with 30 pounds of corn silage. What is this equivalent to in terms of alfalfa hay?

Since one pound of alfalfa hay is equal in feeding value to about 3 pounds of silage, 30 pounds of corn silage will be equivalent to 10 pounds alfalfa hay. Therefore, the ration is equivalent to 35 pounds alfalfa hay and either Chart I or Chart II may be used as if 35 pounds alfalfa hay were actually being fed daily.

CALCULATING TOTAL NUTRIENTS

To use Chart II proceed as illustrated by the following example: Find the total digestible nutrients in the following ration:

36	pounds alfalfa hay
5	pounds barley
0	pounds corn
3.6	pounds millrun

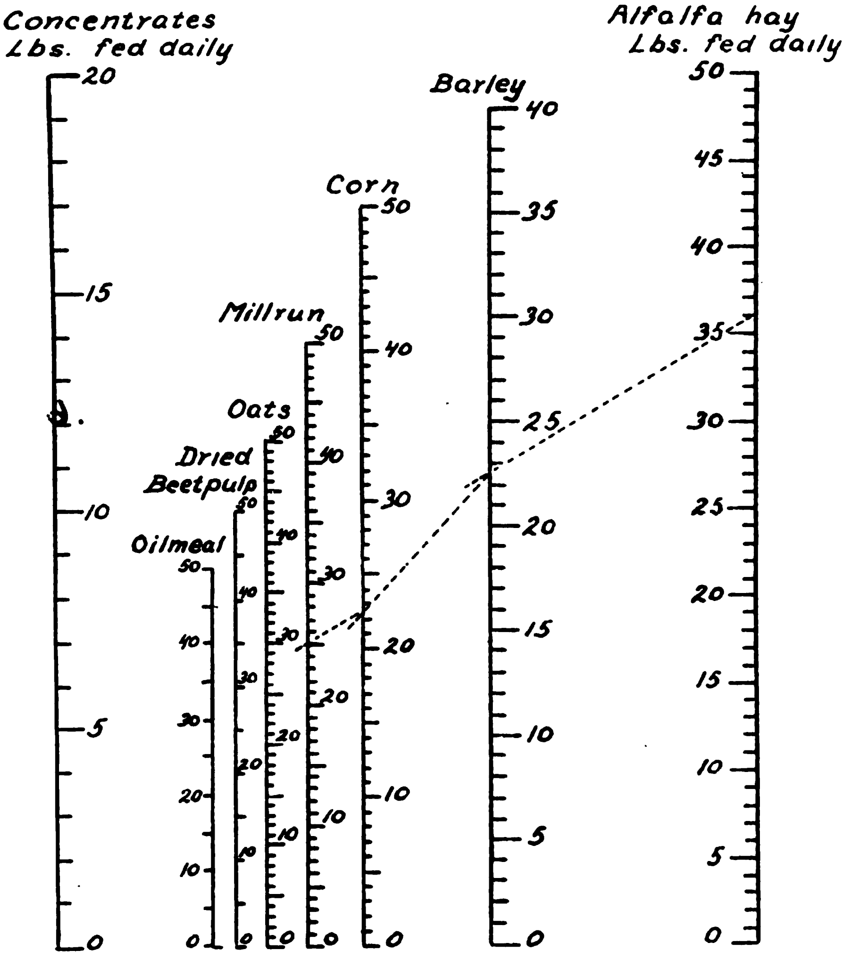
1. Lay a ruler from 36 on the *alfalfa scale* to 5 on the *left-hand scale* and put the point of a pencil where the ruler crosses the *barley scale.*

2. Since no corn is fed, lay the ruler from the pencil point on the *barley scale* to 0 on the *left-hand scale* and put the point of the pencil where the ruler crosses the *corn scale.*

3. Place the ruler from the pencil point on the *corn scale* to 3.6 on the *left-hand scale* and put the point of the pencil where the ruler crosses the *millrun scale.* Note this reading which is 25.0. This means that the ration given above would supply 25.0 pounds total digestible nutrients.

NOTE: In using the chart the feed must always be calculated from right to left in the order given. When in going from right to left it is necessary to pass by a grain that is not fed (as in the case of corn above), it is necessary to go through the motions of making the calculation by laying the ruler from the point of last intersection to zero in the same manner as if this feed were present.

II. TOTAL NUTRIENTS IN DAIRY RATION



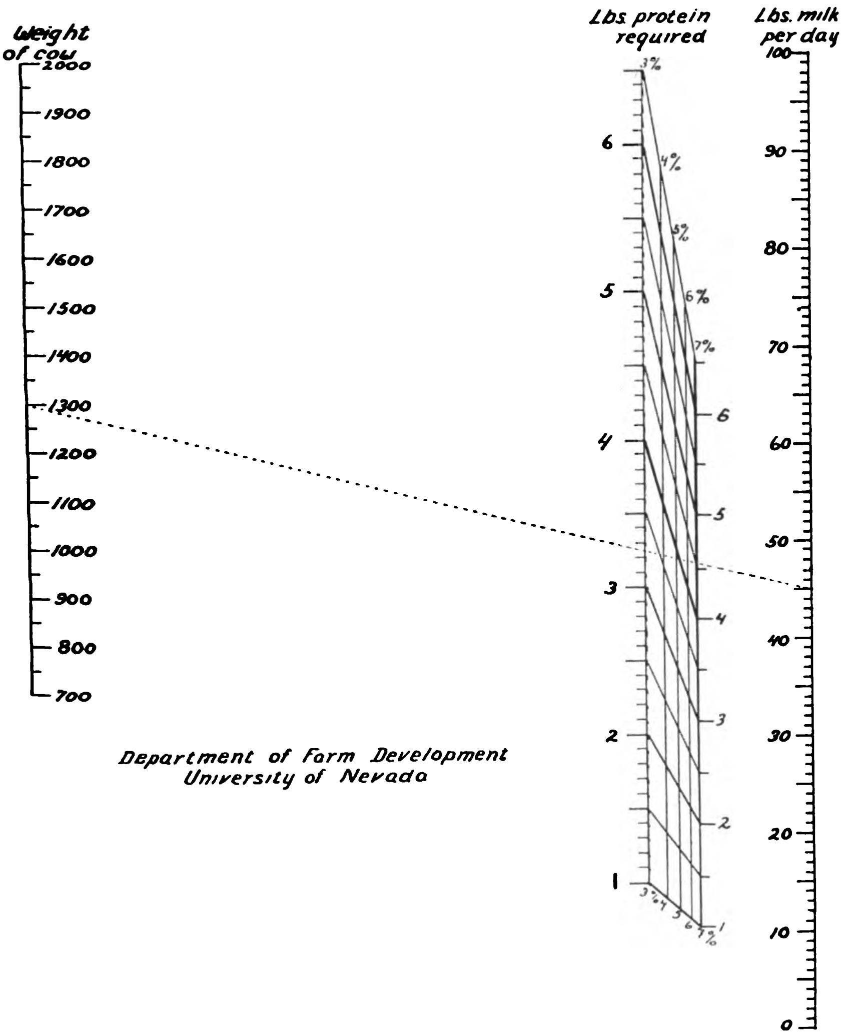
PROTEIN REQUIREMENT OF DAIRY COWS

Alfalfa hay is fed by practically all dairymen in Nevada and as long as alfalfa hay constitutes fifty per cent of the roughage fed, the protein requirements will be fully met without the addition of such protein-rich feed as oil meal. However, when it is desired to calculate protein requirements and protein in any feed combination, Charts III and IV may be used.

Chart III is used in the same manner as Chart I. For example, find the protein requirement for a cow weighing 1,300 pounds giving 45 pounds daily of 4% milk.

Lay the ruler from 45 on the *right-hand scale* to 1,300 on the *left-hand scale* and place the point of the pencil where the ruler crosses the *4% line.* Remove the ruler and note that this reading is 3.6, which represents the number of pounds of digestible protein required by this cow daily.

III. PROTEIN REQUIREMENTS



PROTEIN AVAILABLE IN ANY COMBINATION OF FEEDS

Chart IV is used in the same manner as Chart II. For example: Find the protein in

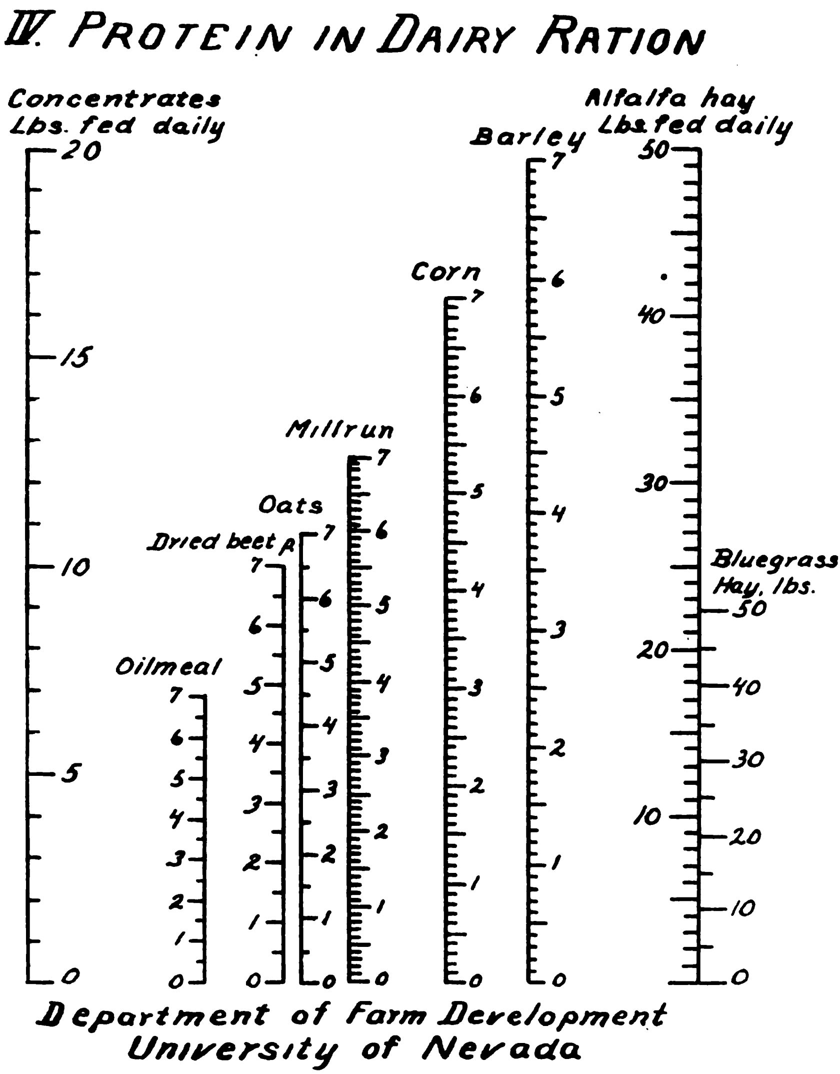
36	pounds alfalfa hay
5	pounds barley
3.6	pounds millrun

1. Lay the ruler from 36 on the *alfalfa scale* to five on the *left-hand scale* and place the point of the pencil where the ruler crosses the *barley scale*. The reading is 4.2 which means that there are 4.2 pounds protein in the above amount of hay and barley.

2. No corn is fed. Place the ruler from the point of the pencil on the *barley scale* to 0 on the *left-hand scale* and put the point of the pencil where the ruler crosses the *corn scale*. The reading will still be 4.2 as on the previous scale.

3. Place the ruler from the point of the pencil on the *corn scale* to 3.6 on the *left-hand scale* and place the point of the pencil where the ruler crosses the *millrun scale*. Remove the ruler and read 4.7. This is the number of pounds of digestible protein in the ration listed above.

This ration provides one more pound of protein than the standard calls for in the example illustrating Chart III. This excess protein comes from the large amount of alfalfa hay fed and may be disregarded. Alfalfa is usually the cheapest feed available for dairy stock, so that any attempt to reduce the protein to the standard requirement would result in economic loss. It has not proven injurious to feed dairy cows a continuous unlimited ration of alfalfa hay with grain supplements, and there is little evidence that continuous feeding of alfalfa hay as roughage is injurious even when continued for the life of the cow.


IV. PROTEIN IN DAIRY RATION
Concentrates Lbs. fed daily
20
15
10
5
0
Oilmeal
7 6 5 4 3 2 1 0
Dried beet p.
7 6 5 4 3 2 1 0
Oats
7 6 5 4 3 2 1 0
Millrun
7 6 5 4 3 2 1 0
Corn
7 6 5 4 3 2 1 0
Barley
7 6 5 4 3 2 1 0
Alfalfa hay Lbs. fed daily
50 40 30 20 10
Bluegrass Hay, lbs.
50 40 30 20 10 0
Department of Farm Development
University of Nevada

TO FIND THE COST OF DIGESTIBLE NUTRIENTS IN FEEDS

When feeds must be purchased for feeding cows or other live stock it is important to know the cost per pound of the digestible nutrients in order that the most economical ration may be procured. To calculate the cost of nutrients by arithmetic is tedious but by the use of Charts IV and V calculation becomes very simple. The cost per pound of total nutrients or of protein at any market price may be found merely by laying a ruler across two points and reading the answer on a scale.

Example: What is the cost of protein in alfalfa hay at $15 per ton and in timothy at $10?

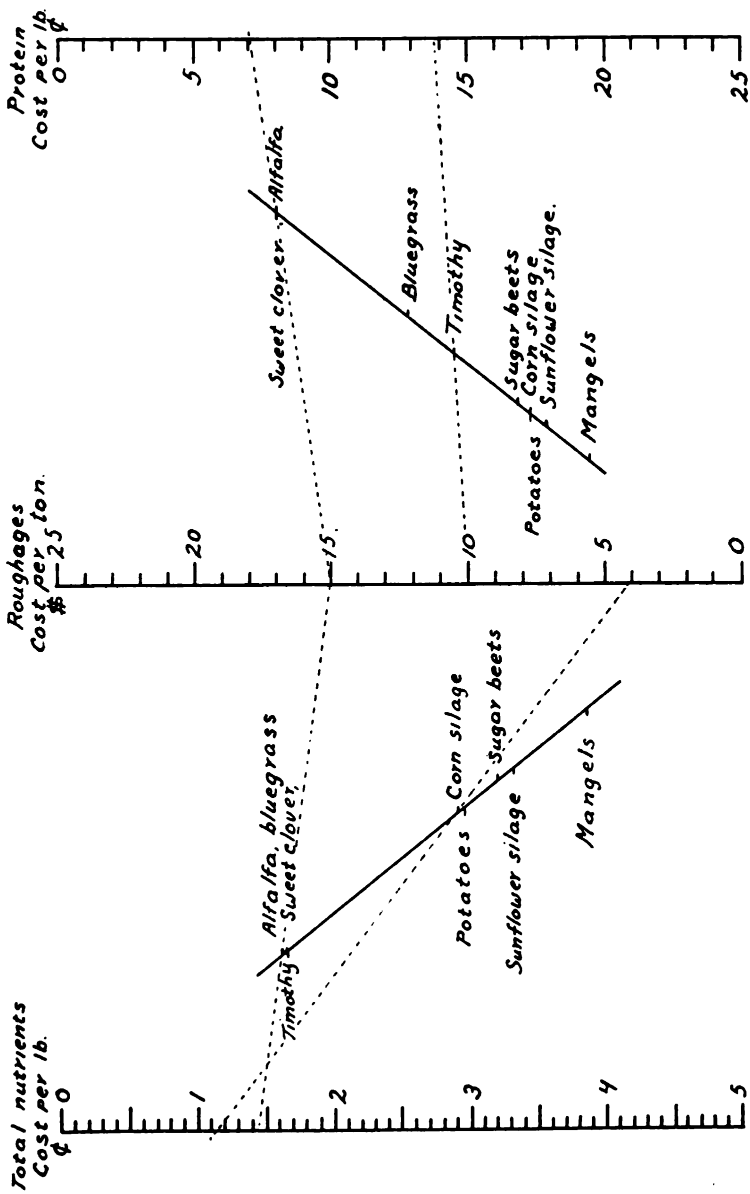
Lay a ruler from 15 on the *central scale* of Chart V to *alfalfa* on the *diagonal scale* to the right and read the cost on the *right-hand scale*, which is in this case 7c. per pound. Next lay the ruler from 10 on the *central scale* to *timothy* on the *diagonal scale*, and read the answer on the *right-hand scale*, which is in this case 14c. Protein, therefore, costs only half as much per pound in alfalfa hay at $15 as in timothy at $10 per ton.

In like manner the total nutrient cost may be calculated on the left half of Charts V or VI for any feed.

Example: What is the cheapest form of total nutrients, alfalfa hay at $15 or corn silage at $4?

Lay the ruler from the price per ton to the name of each feed on the left half of the chart and find that the total nutrients of alfalfa costs 1.2c. a pound while in silage the cost is only 1.0c.

V. COST OF DIGESTIBLE NUTRIENTS IN ROUGHAGES



Department of Farm Development University of Nevada

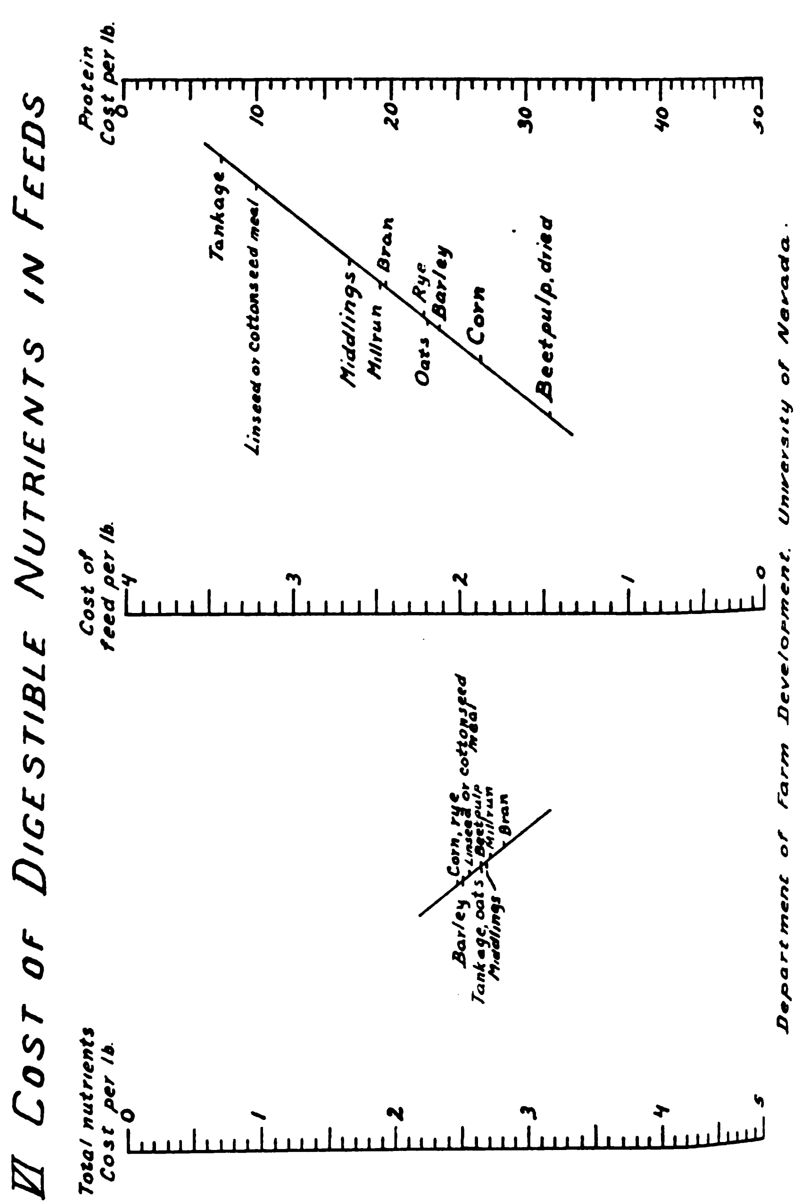

VI Cost of Digestible Nutrients in Feeds
Total nutrients cost per lb.
0 1 2 3 4 5
Cost of feed per lb.
4 3 2 1 0
Protein cost per lb.
0 10 20 30 40 50
Barley
Tankage, oats
Middlings
Corn, rye
Linseed or cottonseed meal
Beet pulp
Millrun
Bran
Tankage
Linseed or cottonseed meal
Middlings
Millrun
Bran
Oats
Rye
Barley
Corn
Beet pulp, dried
Department of Farm Development, University of Nevada.

TABLE I

Analyses of Dairy Feeds Most Commonly Used in Nevada*

Feeds	*Digestible crude protein Per cent*	*Digestible nutrients Per cent*
Grain—		
†Barley, common	9.0	79.4
Corn, dent, grade No. 1	7.4	84.2
†Corn, dent, grade No. 2	7.1	81.7
†Oats	9.7	70.4
Rye	9.9	81.0
By-Products—		
†Beet pulp	4.6	71.6
Cocoanut meal, new process	19.9	70.8
Cocoanut meal, old process	18.6	78.8
Cottonseed meal, choice	37.0	78.2
Cottonseed meal, prime	33.4	75.5
†Oil meal	32.6	75.7
Linseed meal, new process	31.7	75.9
Linseed meal, old process	30.2	77.9
†Wheat bran, all analyses	12.5	60.9
Wheat feed (millrun)	~~[illegible]~~ 12.9	~~73.2~~ 67.0
Dried Roughage—		
Corn fodder, very dry	3.5	58.6
Corn fodder, medium water	3.0	53.7
Corn stover, very dry	2.2	52.2
Sorghum fodder, dry	2.8	52.1
Hay—		
†Alfalfa	10.6	51.6
Alfalfa meal	10.2	50.7
Alfalfa leaves	17.3	60.0
Clover, red, all analyses	7.6	50.9
Clover, sweet	10.9	50.7
†Timothy, early to full bloom	3.6	51.0
†Bluegrass-Kentucky, all analyses	4.7	51.6
Silage and Roots—		
†Sugar beets	1.2	14.0
†Mangel	0.8	7.4
†Potato	1.1	17.1
Pumpkin, field	1.1	6.7
†Corn silage	1.1	17.7
Sunflower silage	1.0	12.6

*Analyses from Henry and Morrison's Feeds and Feeding, 18th edition.
†These analyses used in construction of charts.

TABLE II

Daily Nutrient Requirement of Dairy Cows

Maintenance and Production	*Digestible crude protein Pounds*	*Digestible nutrients Pounds*
Maintenance per 1,000 lbs. live weight	.700	7.925
Per lb. 3 per cent milk	.052	.270
Per lb. 3.5 per cent milk	.056	.295
Per lb. 4 per cent milk	.060	.320
Per lb. 4.5 per cent milk	.064	.350
Per lb. 5 per cent milk	.068	.375
Per lb. 5.5 per cent milk	.071	.405
Per lb. 6 per cent milk	.075	.430
Per lb. 6.5 per cent milk	.078	.455
Per lb. 7 per cent milk	.082	.480

Adapted from Henry and Morrison's Feeds and Feeding, 18th edition.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 117 RENO, NEVADA November, 1929

FACTORS AFFECTING THE COST OF PRODUCTION OF ALFALFA HAY IN WESTERN NEVADA

The results presented in this bulletin have been obtained through the cooperation of individual farmers in western Nevada with the Department of Farm Development. The Bureau of Agricultural Economics of the United States Department of Agriculture has cooperated by the furnishing of supplies and its counsel.

By
F. B. HEADLEY
Chief, Department of Farm Development
and
R. M. CLAWSON
Assistant in Farm Development

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE : : JOE FARNSWORTH, SUPERINTENDENT
1929

1⁵⁰

NEVADA AGRICULTURAL EXPERIMENT STATION

SUMMARY

1. Detailed cost accounts were kept on private farms in the vicinity of Reno, Fallon, Fernley and Lovelock during the three years 1926, 1927 and 1928. Accounts were kept with all enterprises in which the farmers were engaged, but the results in this bulletin apply only to the cost of producing alfalfa.

2. In the area studied alfalfa is the leading farm crop, both from the standpoint of area planted and from net income obtained.

3. At the prices current when the study was made, the cost per ton to produce alfalfa hay varied according to location and yield per acre. The average cost at Fallon was $6.90 per ton, at Fernley $7.87 per ton, and at Reno $11.78 per ton.

4. The yield per acre has a marked effect on the cost of production per ton, and this effect is shown by means of a graph which indicates the extent to which increased yields reduce the cost per ton.

5. The effect of variable seasons on yields and cost is shown for identical farms for three successive years. When alfalfa aphis reduced the yield on the Newlands project in 1927, the cost of producing a ton of hay was increased 18 per cent over the cost for the previous year.

6. The net cost of securing new stands of alfalfa was found to be highly variable. The average net cost was found to be $23.31 per acre at Fallon and $12.90 at Reno.

7. The effect of maintenance of equipment on the cost of producing alfalfa hay is discussed. As a rule the equipment cost per ton becomes less as the area in alfalfa increases.

8. A discussion, supplemented by a graph, is presented showing the effect of the area in crop on the distribution of labor throughout the year.

9. The labor requirement was found to be proportional to the area in crop. The average time on all farms was 26 hours per acre.

10. The effect of location and yield per acre on various kinds of field work is discussed. Furrow irrigation required more labor than irrigation by flooding. The time required per acre to mow, rake, bunch, cock and stack alfalfa hay is given, and the effect of yield on labor requirement is shown by graphs.

11. A table of standard labor requirements is given which should be valuable to farmers as efficiency standards by which they may measure their own efficiency or estimate the labor necessary for work to be done.

12. Charts are given which make it possible to determine quickly the cost of producing alfalfa hay per acre or per ton under almost any

new combination of economic conditions. By utilizing these charts one may recalculate the cost of production at any rate for man labor or horse labor, any interest rate, any land valuation, or any yield per acre.

13. Several examples are given showing how the charts may be used for solving practical examples in hay production costs.

PREFACE

In January, 1926, a new project was started by the Nevada Agricultural Experiment Station which had for its object a study of the cost of production of the crops and live stock produced on the small farms of western Nevada. These costs of production studies are being conducted for the purpose of getting at the basic principles of irrigation agriculture by determining those factors in the conduct of farm enterprises which affect the economy of production. Some of the specific objectives may be stated as follows:

(1) Determination of the most profitable individual enterprises and the factors that affect the profitableness of each.

(2) Determination from the economic standpoint of the desirable combinations of enterprises adapted to the region studied.

(3) Determination of the average unit requirements for each enterprise.

(4) Determining under what economic conditions the opening of new lands for irrigation development or the breaking up of large tracts into small farms may be justified.

This bulletin deals with the factors affecting the cost of producing alfalfa hay and a determination of the unit requirements of the various operations necessary in the production of alfalfa. Other bulletins will follow taking up other phases of this study.

FACTORS AFFECTING THE COST OF PRODUCTION OF ALFALFA HAY IN WESTERN NEVADA

METHODS OF SECURING DATA

About thirty cooperating farmers were secured each year who volunteered to keep cash accounts of all moneys received and expended and to keep a diary of all labor performed on the farm. These records were inspected and collected weekly by a route man who mailed them into the central office for posting. The route man also took such other notes as might be necessary regarding rations fed to live stock, crops planted, and other essential information. At the central office all records were promptly posted to their proper ledgers in order that errors or omissions might be quickly detected.

The number of cooperators who kept records on the growing of alfalfa in each district for the years 1926, 1927 and 1928 was as follows:

Year	*Reno*	*Fernley*	*Lovelock*	*Fallon*	*Total*
1926	7	6	2	11	26
1927	5	5	0	12	22
1928	4	4	0	15	23

In securing cooperators it is not intended that they be selected from among the best farmers, but usually it is only the better type of farmers who will enter into cooperation of this sort. The averages given therefore do not represent mass averages, but averages obtained on farms operated by good farmers, whose methods are slightly more efficient than those of the mass. In interpreting these averages it should be kept in mind that the costs given are probably lower than the average for the districts as a whole, for the reason that most of the cooperators are somewhat better than average farmers.

In these studies, labor and materials used or produced have been valued at the general market price for the locality. Labor of the family and any labor that might be donated by neighbors is valued at the cost of equivalent hired labor. Hay fed to live stock is credited as if it had been sold to the stock at market prices.

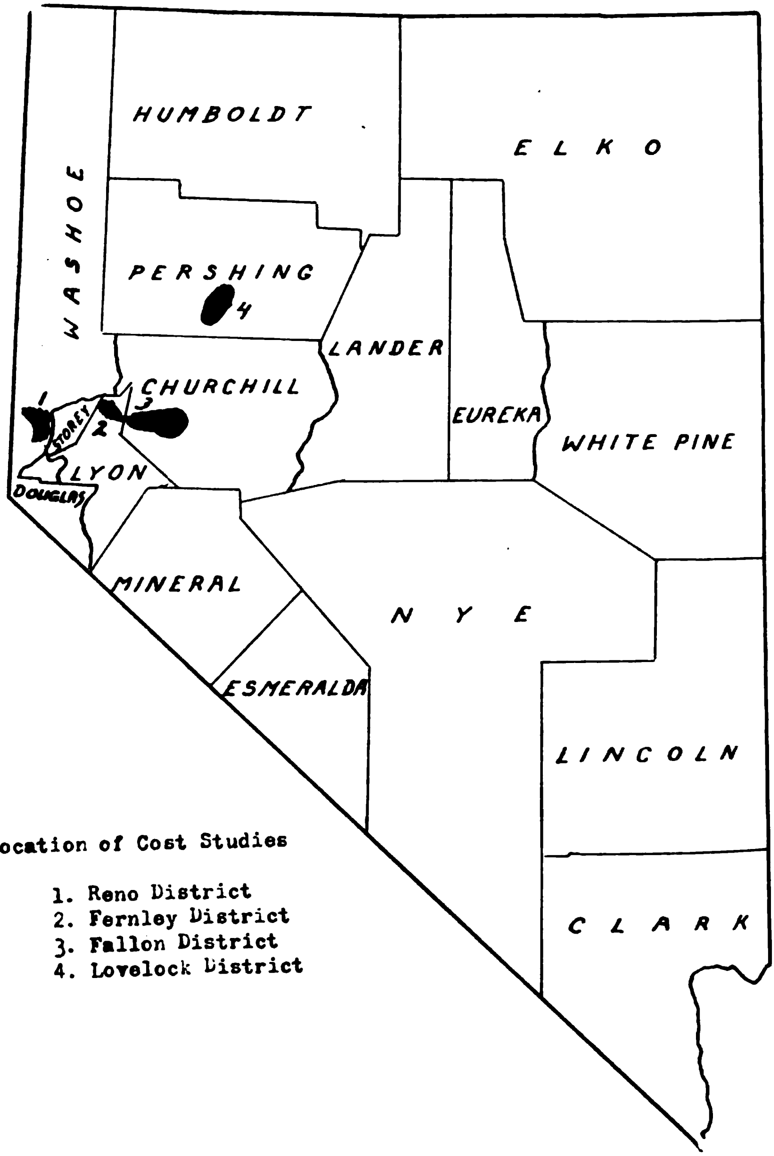
AREAS STUDIED

The areas studied lie in the counties of Washoe, Lyon, Churchill and Pershing, as indicated by the black shading on the accompanying map of Nevada. In the Lovelock area only two farms cooperated for one year, but as the soil, climate and agriculture of that section are similar to that of the Fallon area, the data acquired at this place are considered to be applicable to the Lovelock section.

The Reno and Fernley districts receive their water supply from the Truckee River, Lovelock from the Humboldt River, and Fallon from the Carson River, supplemented by additional water from the Truckee. In 1926 and 1928 irrigation water was short along the Truckee and Humboldt Rivers, which resulted in reduced yields of third-crop hay in the region irrigated by these streams, but the yields at Fallon were not materially affected by water shortage during any of the three years.

The results of this study of the cost of producing alfalfa hay are

applicable to all irrigated sections where alfalfa hay is raised by similar methods, or may be made to apply by readjusting some of the values as will be explained later in this bulletin. The results for mowing will not apply where tractors are used for mowing, and the



Location of Cost Studies

1. Reno District
2. Fernley District
3. Fallon District
4. Lovelock District

results for stacking will not apply where loaders are used for loading the hay onto the wagons. The methods included in this study are those commonly used on small irrigated farms.

WEATHER CONDITIONS

The weather conditions in western Nevada are favorable to the production of alfalfa hay of the highest quality. The rainfall in summer is negligible, and the hay is seldom damaged by rains during the harvesting period. For this reason the hay usually goes into the stack and comes out with the bright green color so characteristic of the hay produced in the arid sections of the United States.

Because of the elevation above sea level (3,900 to 4,600 feet) and the proximity of snow-capped mountains, the area in which this study was made is subject to late spring frosts, but these are seldom severe enough to damage the growing alfalfa. The nights are usually cool and the days hot during the growing season.

TABLE I - MEAN MONTHLY PRECIPITATION DURING GROWING SEASON

Month	*Reno*	*Fernley*	*Fallon*	*Lovelock*	*Mean*
May	.63	.51	.56	.43	.50
June	.29	.21	.29	.54	.33
July	.25	.24	.15	.20	.21
August	.22	.18	.23	.15	.20
September	.26	.18	.28	.28	.25
October	.36	.28	.42	.37	.36
Annual	8.10	5.50	4.67	3.90	5.54

MARKET CONDITIONS

The Reno district does not produce sufficient alfalfa hay to supply its own needs and it has been necessary, at least during recent years, for consumers to import some hay from Fallon and other points. This has led to a marked difference in the price of hay between Reno and the localities that export alfalfa hay. The price of alfalfa at Reno is usually $4 to $6 a ton higher than at Fallon.

At Fallon, Lovelock and Fernley more hay is produced than is required for consumption by the live stock on the farms. The excess is marketed in two ways: (1) By bringing in cattle and sheep from the ranges for winter feeding, and (2) by grinding the hay into alfalfa meal for eastern markets. Before the advent of the alfalfa weevil into Nevada most of the excess hay not required by local stock or by feeders was baled and shipped to California markets. Since the establishment of the California quarantine against baled hay from weevil-infected areas, eastern markets for alfalfa meal have been found, and the price farmers receive for their hay has remained at a fairly satisfactory level. A strong demand for the alfalfa meal will undoubtedly continue, because the hay of which the meal is made is usually cured under ideal climatic conditions and meal of exceptional quality is therefore obtained.

IMPORTANCE OF ALFALFA AS A CROP

Alfalfa is the chief money crop as well as the main source of forage for live stock in the area included in this study. No records are available as to the acreage planted to the various crops in the Reno district, but an annual farm census has been taken on the Newlands Project since it was opened by the Reclamation Service. These reports show that alfalfa constitutes 60 per cent of the total irrigated area and 77

per cent of the area actually in cultivated crops. About 17 per cent of the total irrigated area is wild grass pasture. Three-fourths of the cultivated land has been kept in alfalfa since 1912. The remaining 25 per cent is utilized for grain, cantaloupes, gardens and minor crops. It is practically a one-crop system of agriculture.

A one-crop system is usually looked upon as uneconomical and subject to wide fluctuations in income, but these investigations indicate that in the Newlands Project no other crop approaches alfalfa in uniformity of yield, demand and price. The average net profits obtained by the cooperating farmers were greater for alfalfa than for any other crop. When it is once established on good soil in this project alfalfa remains highly productive for ten or more years, and it is not uncommon to see fields more than 20 years old. No long-time annual records of yields are available, but the general opinion seems to be that the yield slowly declines after the alfalfa is eight or ten years old.

In the Reno district conditions are different from those of the Newlands Project, and alfalfa must be rotated with other crops at comparatively frequent intervals. If this is not done, blue grass and bronco grass (*Bromus tectorum*) invade the fields and reduce the yield and quality of the alfalfa hay. The average yield of alfalfa is generally smaller in the vicinity of Reno than in the Newlands Project, but this is compensated by the fact that the potato and grain yields are generally greater. In this section diversification of crops is necessary to a profitable agriculture, while in the Newlands Project diversification may result in a reduction of the net income.

EXPLANATION OF TERMS

Costs are usually thought of in terms of money, but dollars and cents are in reality a poor measure of labor or materials. The dollar is constantly changing in value, so that to use it as a measure of cost is very much like using a yard stick that is constantly changing in length for the purpose of measuring the size of objects. Whenever prices change either up or down, the value of the dollar has changed to an equal amount but in the opposite direction.

Money costs of producing farm products will be used to some extent in the presentation of the results of this work, but it should be kept in mind that money costs are of only temporary value, and it is for this reason that all results will either be presented in physical quantities or else the money cost, wherever possible, will be proportional to definite physical units. By doing this, costs may be recalculated to fit any other combination of prices that may obtain at any other time or place.

Labor requirements of operations conducted in a similar manner do not change materially because of location in place or time. The labor required in Nevada for many farm operations has been found to be practically the same as in a number of other States where investigations were conducted one or two decades ago. When actual money costs of these operations are compared there is little or no relationship. If these results had been presented at that time in money costs only, no worth-while comparisons would be possible, and those records would have no value at the present time except for their historical interest.

While the money costs expressed in dollars and cents may change from year to year, the physical requirements such as labor, seed, twine, etc., will hold until there is some radical change in the character of the machinery used. For example, when the combine harvesters came into general use a radical change took place in amounts of labor required. Such general changes in equipment as this seldom occur, however, and until they do records of labor requirements show little change. It would be of no value to publish the money cost alone of harvesting and stacking alfalfa hay, but it is valuable to know the average number of man and horse hours required per acre to mow, rake, cock and stack the hay with different types of equipment, so that the actual cost can be calculated at any time or place regardless of the economic changes that may have occurred.

Man Labor—Each cooperator kept a daily record of the hours of labor spent by each worker on all the enterprises of the farm. All the labor used directly in the production of alfalfa was charged against the field work in the alfalfa ledger. The time spent on the upkeep of ditches was apportioned among all the crops of the farm according to acreage. The time spent in the care and repair of machinery was charged in the equipment account and apportioned among the crops, not according to acreage, but on the basis of the number of hours used on each crop. General farm work or overhead was apportioned as equitably as possible among all the enterprises of the farm.

The work of children was calculated to its adult equivalent. A boy might be classed as two-thirds of a man while cocking hay, but would do a man's work while driving derrick or raking.

In calculating costs a flat rate of 40 cents per hour was used for all man labor, since this is approximately the average wage rate when the cost of board is included. In some cost studies the actual wage rates plus board (a figure which constantly changes from month to month) has been used, but results from such methods are of only temporary value. It was thought best to use a flat rate which would permit recalculation for any other wage rates that may obtain as economic conditions change. All labor costs in this bulletin may be easily recalculated for any other labor rates.

When a constant labor rate is used on all farms, comparisons in efficiency of operation may be made between any number of farms by comparing money costs, but if different labor rates are used, differences in costs or profits might be due, not so much to variations in efficiency as to differences in the wages paid.

Horse Labor—The work performed by horses is recorded by the cooperating farmers in the same manner as the man labor, and the costs of horse labor are distributed among the farm enterprises in the same way.

The annual cost of keeping a work horse is nearly constant, regardless of the amount of work performed. For this reason the cost per hour varies widely on individual farms, depending upon the number of hours the horses work per year. The average cost per hour of horse labor was found to vary between 11 and 13 cents on the cooperating farms during the three years 1926, 1927 and 1928, and 12 cents

was adopted as the rate to use in these cost studies for all horse labor performed. The reasons for using a flat rate for horse labor are the same as those given for man labor. By using a flat rate a man's efficiency or inefficiency in keeping his horses is not reflected in the cost of producing his crops as is the case when actual costs of horse labor are used.

Equipment Costs—The cost of repairing and caring for all farm equipment is apportioned among the enterprises on which each piece of equipment is used. Equipment costs include depreciation, cash repairs, a share of the taxes, labor in making repairs and cost of shelter if any. Depreciation is based on the average life of the machines. The sum of these costs is apportioned among the crops on which the machines are used. The apportionment is made on the basis of the number of hours each machine is used on the various enterprises.

Interest on Investment—In all these cost studies interest at 6 per cent on investment has been included. This charge for interest is so arranged in the table that it may be omitted or the rate may be changed at will by simple proportion. The land on which interest was calculated was classified as nearly as possible at uniform prices for lands of equal productive capacity in each district, so as not to obscure the relative efficiency of individual farmers in the actual production of the crop. Interest was calculated on the value of the land, equipment and value of the irrigation structures.

Overhead costs have been included among the other costs of producing alfalfa, although overhead is not a direct cost in the production of alfalfa. In many reports on production costs this item is omitted entirely, and for this reason the significance of the term should be clearly understood. On every farm a certain amount of labor and cash costs are necessary to the maintenance of the farm business but which cannot be charged directly against any of the individual enterprises. Such costs include the care of the farmstead, cost of general equipment, building of roads and bridges in the fields, water charges and taxes on farmstead, waste land and fallow land, the recording of mortgages, the trapping of rodents and other general items of this class. At the close of each year these general expenses are summarized and apportioned among all the farm enterprises. This charge against alfalfa is kept separate from miscellaneous cost so that it may be omitted by those who do not look upon it as an essential cost.

Under *sundries* will be found all cash costs commonly classed as overhead, but not so used in this bulletin. Items included under this title are taxes, water charges, upkeep of irrigation system, equipment and miscellaneous. Miscellaneous charges are small, and on many farms there is no cash outlay under this heading.

The *average* as used in this bulletin is obtained by dividing the sum of any series of determinations by the number of determinations. For example, the number of hours required to mow an acre of alfalfa may be found on each of 20 farms. These results are added together and divided by 20, resulting in what is called the average time to mow an acre of alfalfa. It gives equal weight to all farms whether they are large or small.

The *weighted average* is derived in such a way as to give weight according to the number of acres or tons or other units. For example, to find the weighted average for mowing it would be necessary to find the total number of hours used in mowing on all farms and divide by the number of acres. By this method one large farm having a thousand acres of alfalfa would have as much influence in determining the weighted average as 20 small farms of 50 acres each.

Median—Frequently the median is more significant than either the average or weighted average. It is derived by arranging a series of results in order of magnitude and selecting the middle number as the median. For example, the time required to mow an acre of land on five farms is found to be .9, .95, 1.1, 1.25 and 1.4 hours. The median is the middle number 1.1 hours. One-half of the remaining farms are arranged on either side of this number. The average of the above series would be 1.12 hours.

Middle-class range is determined by arranging the results in the order of magnitude and selecting the middle half. The range then extends from the two extremes of this middle group. For example, in the following series of numbers .85, .90, *1.00*, *1.05*, *1.12*, *1.15*, 1.20, 1.30, the middle-class range extends from 1.00 to 1.15. The middle-class range is valuable in that it gives an idea of what may be termed the typical range or the range in which the middle half of the farms lie.

COST OF PRODUCTION PER ACRE OF ALFALFA HAY

The total cost per acre of producing alfalfa hay varies somewhat in different districts because of factors over which the farmers have no control. For instance, in the Reno and Fernley districts the fields are best irrigated by the furrow system, while at Fallon the flooding method is used. This latter method reduces the amount of labor required. In the Reno district land values are high, which has the effect of increasing the taxes and interest on investment. Other differences in costs are not large or significant. In Table II the average cost of production for each of the three districts is shown. (See page 14.)

The average total cost of production was $28.70 per acre or $6.90 per ton at Fallon; $36.42 per acre or $7.87 per ton at Fernley, and $36.76 per acre or $11.78 per ton at Reno.

The relationship of the items that enter into the total cost of production is best shown in the form of graphs. In Chart I is shown the cost per acre of producing alfalfa in each of the three areas. These graphs show that the cost of man labor is highest in Fernley. The detailed records of labor indicate that this high man-labor cost at Fernley is due to furrowing and extra labor spent in irrigating, especially previous to the first crop. The actual cost per acre of producing alfalfa hay is not much higher at Reno than at Fallon, when interest on investment is not included, but it should be kept in mind that about two and one-quarter cuttings are made per year at Reno while at Fallon and Fernley three cuttings are almost always made. If three cuttings were made at Reno the labor cost would be nearly the same as at Fernley. The higher valuation of lands in the vicinity of Reno materially increases the charge for interest on investment. (See page 15.)

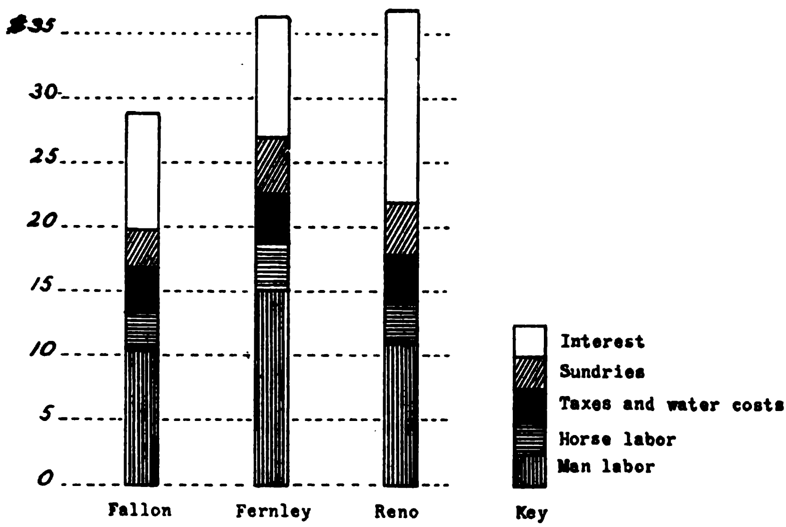
TABLE II—COST OF PRODUCING ALFALFA HAY PER ACRE

	Fallon	Fernley	Reno
Man labor @ 40¢ per hour—			
Field work	$9.78	$13.77	$10.39
Irrigation system	.79	1.28	1.06
Equipment	.45	.45	.55
Overhead	.25	.31	.32
Totals	$11.27	$15.81	$12.32
Horse labor @ 12¢ per hour—			
Field work	$3.34	$3.71	$3.03
Irrigation system	.28	.08	.06
Equipment	.04	.01	.02
Overhead	.03	.03	.05
Totals	$3.69	$3.83	$3.16
Interest @ 6%—			
Land in crop	$8.92	$8.61	$14.59
Irrigation system and equipment	.61	.81	.96
Overhead	.29	.49	.71
Totals	$9.82	$9.91	$16.26
Sundries—			
Taxes	$1.49	$2.17	$2.88
Water charges	1.61	1.80	1.23
Irrigation system and equipment	1.77	2.01	2.33
Miscellaneous	.25	.58	.95
Overhead	1.25	1.79	1.19
Totals	$6.37	$8.35	$8.58
Grand totals	$31.15	$37.90	$40.32
Pasture credit*	$2.45	$1.48	$3.56
Net cost per acre	$28.70	$36.42	$36.76
Yield per acre, tons	4.16	4.63	3.12
Cost per ton	$6.90	$7.87	$11.78

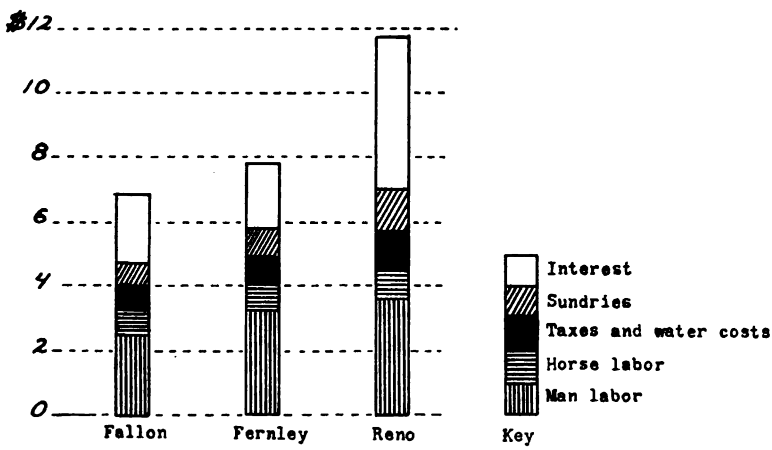
*Pasture rate—$3 per month per head during spring, summer and fall; 75¢ per month during winter.

I. COST OF PRODUCING ALFALFA HAY

Per Acre



Cost Per Ton



EFFECT OF YIELD ON COST OF PRODUCTION

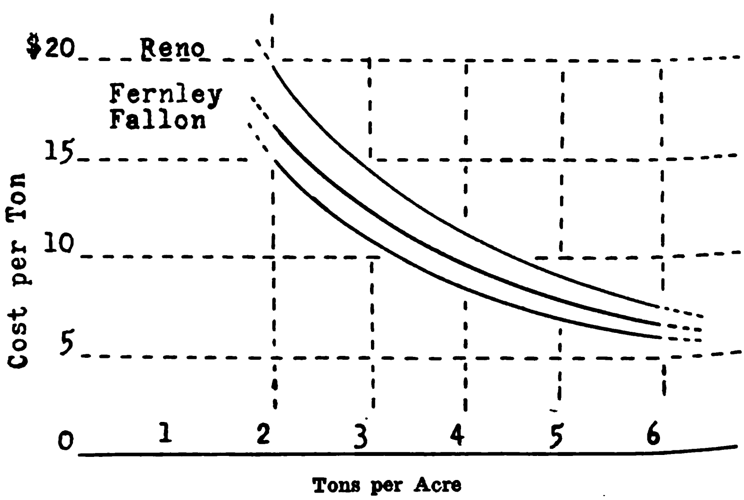
In Table II the average cost per acre was given without taking into consideration the yield per acre. When the farms are grouped according to yield per acre some very interesting results are obtained, for it shows the extent to which the cost per ton is reduced as the yield per acre increases. When the total cost of producing alfalfa is averaged according to yield per acre, the cost per acre and per ton for Fallon, Fernley and Reno are as shown in Table III and Chart II.

TABLE III—RELATION OF TOTAL COST OF PRODUCING ALFALFA HAY TO YIELD PER ACRE

Total cost	Yield per acre, tons				
	2	3	4	5	[illegible]
Fallon—					
Per acre	$29.82	$31.10	$32.28	$33.42	[illegible]
Per ton	14.91	10.37	8.07	6.68	[illegible]
Fernley—					
Per acre	34.32	35.60	36.78	37.92	[illegible]
Per ton	17.16	11.87	9.20	7.58	[illegible]
Reno—					
Per acre	39.29	40.49	41.66	42.80	[illegible]
Per ton	19.65	13.50	10.41	8.56	[illegible]

NOTE—Pasture value not credited in this table.

II. EFFECT OF YIELD PER ACRE ON COST PER TON



It is very evident that it pays in more ways than one to get good yields, for not only are there more tons for sale or for the use of live stock, but the actual cost of producing each ton decreases as the yield increases. For instance, at Fallon with a yield of 3.5 tons per acre it costs $9.10 per ton to produce the crop, but when the yield is 5 tons per

acre the cost is reduced to $6.68 per ton. This is because certain costs per acre such as taxes, water charges, irrigation costs, interest on investment, overhead, and much of the field labor are not materially affected by the yield. About the only costs that do increase with the yield are bunching, cocking and stacking.

On most farms the yield per acre depends to so great an extent upon the character and fertility of the soil and the abundance of the irrigation water that the owner of the land often cannot increase his yields by any practicable means. However, the results given above indicate that a farmer would be justified in going to considerable expense when he is certain that by doing so his yield per acre can be materially increased.

There is no direct answer to the question "what does it cost per ton to produce alfalfa hay?" for the reason that cost per ton is more dependent on yield than on any other one factor. In Table II the average cost of producing alfalfa hay by the farmers who cooperated in this work was shown to be $6.90 per ton at Fallon and $7.87 per ton at Fernley. According to the annual census taken by the Reclamation Service the average yield of the project as a whole is about 3.5 tons per acre annually. Now, a yield of 3.5 tons per acre would cost something over $9 per ton. This relatively high cost per ton on the Newlands Project results from the fact that many acres of low-producing marginal lands are included in the census. The better class lands of the project produce from 4 to 6 tons of alfalfa per acre annually, and on these the cost of production per ton varies between the limits $6 and $9 per ton according to yield and location. The average yield on our cooperating farms near Fallon was 4.16 tons per acre, which was produced at a cost of $6.90 per ton.

EFFECT OF SEASON ON YIELD AND COST

The yield of alfalfa and other crops varies from year to year as a result of natural conditions over which farmers have little or no control. In 1927 the first crop of alfalfa at Fallon and Fernley was attacked by alfalfa aphis which reduced the yield below that of either 1926 or 1928. During the three years 1926, 1927 and 1928 complete records for each year were obtained from nine farms at Fallon and Fernley and from four farms at Reno, and by taking the results from these farms it is possible to get a measure of the effect of season on yield and cost.

At Fallon and Fernley the yield was lower in 1927 than in either 1926 or 1928, and this low yield is reflected in the average cost per acre and per ton as follows:

	1926	*1927*	*1928*
Average yield per acre in tons	5.30	3.90	4.70
Average cost yer acre	$31.77	$27.72	$30.38
Average cost per ton	6.00	7.10	6.47

At Reno the alfalfa aphis was not present in 1927 in sufficient numbers to materially affect the yield, but the yield of alfalfa near Reno was reduced in 1926 by a shortage of the supply of irrigation water. The following table shows that the cost of production per ton

had an inverse relationship to the yield per acre, that is, as the yield per acre increased the cost of producing a ton of hay was reduced:

	1926	*1927*	*1928*
Average yield per acre in tons	2.75	3.22	3.35
Average cost per acre	$32.60	$35.98	$37.05
Average cost per ton	11.85	11.18	11.08

COST OF SECURING A NEW STAND OF ALFALFA

One of the important costs in connection with alfalfa raising is the cost of securing a new stand of alfalfa when the old one has run out to the point where profitable yields are no longer secured. It is a common practice to plant some kind of grain as a nurse crop with the alfalfa, although sometimes alfalfa is planted alone and successful stands secured. When grain is planted the income from the grain helps to pay the cost of the new seeding. Indeed, in some cases the yield of the grain is large enough to more than pay all costs of the new seeding, and the new stand of alfalfa has actually cost nothing. There is no question but that plowing up poor stands of alfalfa is profitable in those localities where the income from the nurse crop pays for the new seeding. However, if it is difficult to secure a new stand and there is but little prospect of enough by-product to balance the costs, then the farm owner should carefully balance the cost of this new seeding against the increased yields which he can expect to gain from it in order to decide which is the more profitable course. Occasionally other crops than grain, such as Sudan grass, are planted as a nurse crop, and the resulting crop used for hay instead of grain. When the nurse crop does not pay for the cost of securing a new stand of alfalfa then this cost must be borne by the succeeding crops of alfalfa up to the time when it is again plowed up and reseeded. In some places high-yielding stands twenty to thirty years old are common, but in other districts a stand of alfalfa may be counted upon to give profitable yields for a period of only four or five years.

In the following table, costs are given of securing stands of alfalfa at Fallon and Reno:

TABLE IV—COST OF SECURING NEW STANDS OF ALFALFA AND NURSE CROPS

	Fallon	Reno
Total man hours @ 40¢	$13.99	$12.75
Total horse hours @ 12¢	7.73	5.08
Total interest @ 6%	9.23	17.10
Water charges and taxes	2.73	4.78
Equipment cost and irrigation system	1.87	3.33
Overhead	1.48	1.38
Sundries	.19	.03
Alfalfa seed	3.88	4.16
Grain seed, threshing cost, twine, binding cost, etc.	4.16	5.24
Total cost	$45.26	$53.85
Total credits	21.95	40.95
Net cost	23.31	12.90

When the interest charge is subtracted from the total cost of producing a stand of alfalfa and nurse crop at Fallon and Reno, it is

found that the resulting cost per acre is almost identical in the two localities, viz, $36.03 at Fallon and $36.75 at Reno. With the labor rates used, the cost of securing a new stand of alfalfa together with the nurse crop is approximately $36 per acre when no charge is made for interest.

From this cost should be subtracted the value of the grain, hay and pasture secured the first year. At Fallon these credits averaged $21.95 per acre, while at Reno the credits were $40.95 per acre. The costs are not widely variable between individual farms, but the credits are extremely variable. This results in a widely varying net cost on individual farms.

Not only is the net cost of securing a new stand extremely variable, but the length of time the fields are left in alfalfa also varies widely, so that it is difficult to establish a uniform charge for the securing of stands. According to Table IV the net cost is $23.31 at Fallon and $12.91 per acre at Reno. If the average life of an alfalfa field is assumed to be 10 years at Fallon and 5 years at Reno, the average annual charge per acre would be: Fallon $2.23, and Reno $2.58. For rough approximations an annual charge of $2 per acre might be added to all cost of production charges given elsewhere in this bulletin. This "cost of seeding" charge has not been added to the costs given in the tables and charts because it is so variable that it should always be applied to fit the peculiar conditions of individual farms or localities.

COST OF ALFALFA EQUIPMENT

Included among the sundry expenses for producing alfalfa is the item of equipment expense. This includes all the equipment used in the production of alfalfa hay, chiefly mowers, rakes, wagons and derricks. Certain other machines are used in a minor way for such operations as furrowing, hauling manure, and cultivating. It is found that large farms have less invested per acre in equipment than small farms. Fields under 30 acres can be harvested with machinery consisting of one mower, one rake, two wagons and a derrick. By adding an extra mower and wagon, double the area can be handled. That is, the expense for machinery does not increase in proportion to the area farmed.

The average cost for operating wagons, mowers, rakes and derricks is given in Table V, which shows the effect of the amount of work done on the cost of operating the various machines. Wagons are reported on the basis of annual costs, since they are used for many other purposes than putting up alfalfa hay. Mowers and rakes are reported on the basis of the number of acres actually harvested each year, since the tonnage does not materially affect the cost of operating either. The cost of operating derricks varies in proportion to the number of tons of hay stacked rather than in proportion to the area. When the yield per acre is known, the cost per ton for each machine can be calculated from the table. The cost per acre or per ton becomes less as the amount of work done is increased. It can be seen that farms with a small area per machine have a larger cost than farms with a larger area per machine.

TABLE V—EFFECT OF WORK DONE ON THE COST OF OPERATING ALFALFA MACHINERY

Area in alfalfa per wagon	Cost per acre per year	*Area mowed or raked per machine during year	Cost per acre		Derricks	
			Mowers	Rakes	Hay stacked per derrick per year	Cost per ton
Acres	*Cents*	*Acres*	*Cents*	*Cents*	*Tons*	*Cents*
10	93	30	51	23	50	29
20	63	40	43	18	75	21
30	47	50	37	14	100	17
40	37	60	33	12	125	14
50	30	70	30	11	150	13
60	26	80	28	10	175	12
		90	27	10	200	11
		100	26	10	225	10
		125	25	10	250	9
Weighted average	52½	Weighted average	29½	10½	Weighted average	13½

*Twenty acres harvested three times makes 60 acres covered during year, or 20 acres mowed twice makes 40 acres during year.

CALCULATING COST OF MACHINERY

The cost per acre for harvesting equipment can be calculated from Table V. For example, let it be assumed that 30 acres of alfalfa hay are cut three times and the yield per acre is four tons. What is the cost for machinery?

If one wagon is used the cost will be 30 acres at 47c, or $14.10. If three wagons are used the cost will be 3 times 10 acres at 93c, or $27.90.

If one mower is used 90 acres will be mowed and the cost will be 90 acres at 27c, or $24.30. If two mowers are used 45 acres will be mowed per mower and the cost will be 2 times 45 acres at 40c, or $36.00.

The cost for the rake will be 90 acres at 10c, or $9.

The cost for the derrick will be 120 tons at 15c or $18.

	1 Wagon and 1 Mower	3 Wagons 2 Mowers
Wagon cost	$14.10	$27.90
Mower cost	24.30	36.00
Rake cost	9.00	9.00
Derrick cost	18.00	18.00
Total cost	$65.40	$90.90
Cost per acre	2.18	3.03
Cost per ton	.55	.76

This example indicates that the use of two extra wagons and an extra mower would increase the cost for machinery 21 cents per ton, but this would be compensated at least in part by the saving in labor resulting from the extra equipment.

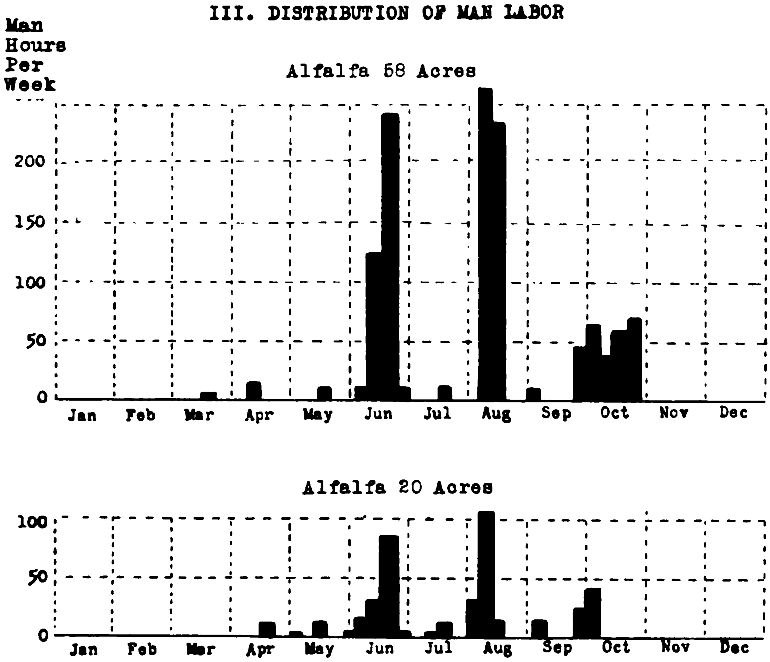
DISTRIBUTION OF LABOR THROUGHOUT THE YEAR

Most of the work of alfalfa production falls within a short space of time. The intercrop work can be performed through fairly wide intervals of time and does not need to be concentrated within a short period, but in harvesting alfalfa there is very little choice as to the best time to mow, for when harvesting is once begun, raking and stacking must be performed in regular sequence without undue loss of time or the quality of the hay will be damaged.

How the work "piles up" during the three harvesting periods is

indicated graphically on Chart III. The upper part of Chart III represents the distribution of labor performed on a 58-acre field of alfalfa, and the lower part represents the distribution on a 20-acre field. It can be seen that the labor of putting up the first and second crops is performed as quickly on the large farms as on the small one. Extra hours of labor required on the large farm cannot be stretched out over a longer period of time, but must be provided during the 10 or 15 days when the hay is at its best. In the case of the third cutting, cooler weather prevails and the time of putting it up is extended over a longer period.

III. DISTRIBUTION OF MAN LABOR



EFFECT OF ALFALFA AREA ON AMOUNT OF LABOR TO BE PROVIDED

Since the work of harvesting alfalfa must be done quickly, the proprietor is unable to do all of the work alone. Even with very small areas it is economical to secure help, because some of the operations cannot be done to advantage by one man.

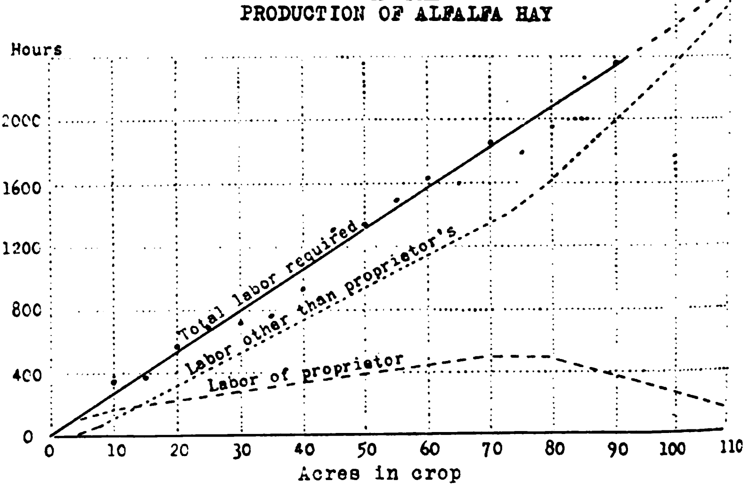
In Chart IV is shown the effect of the total area in alfalfa on the total hours of man labor required. The dotted lines also indicate approximately the amount of labor supplied by the proprietor and the amount of labor other than his own that the proprietor must supply. The labor "other than proprietor's" may be that of his own family in whole or in part. A curve showing the amount of labor supply by the proprietor's family would be useless because of the variability in the size of families.

The solid line in Chart IV shows the average number of hours of

man labor required for the production of alfalfa hay in the Fallon-Fernley-Reno region for alfalfa areas of varying sizes. The average labor required per acre is 26 hours. The labor of the proprietor increased slowly as the total area increased up to 70 or 80 acres and then declined. It appears that as the total area increased above 80 acres in alfalfa, the proprietor begins to spend less of his own time in the actual labor of harvesting the crops and substitutes the labor of others. On some of the larger farms the proprietors have spent more time in the management of the hay crews, but time used in management has not been charged in this study as labor. Presumably for very large areas (not represented in this study), the proprietor would not spend any of his own time in actual field operations and all the work would be performed by other laborers.

In this chart the curve for total labor required is a reasonably close fit to the averages for the groups, but the curve representing the amount of labor of proprietor is approximate only, especially beyond the 60-acre point. Beyond this the individuality of the different proprietors shows up more strongly, some still working as hay hands while others turn over a larger part of the field work to hired help.

IV. TOTAL HOURS OF MAN LABOR REQUIRED IN THE PRODUCTION OF ALFALFA HAY



INTERCROP WORK

By intercrop work is meant all work (except irrigating) performed on the alfalfa fields outside of the actual harvesting of the crop. It includes such items as upkeep of the irrigation system, upkeep of hay equipment, hauling manure, furrowing, etc. This work varies widely in amount on different farms because much depends upon the individual requirements of the field and upon the distinctive methods adopted by different farmers. Yield per acre does not materially affect these labor requirements. The average time spent in intercrop work is shown in Table VI.

TABLE VI—AVERAGE HOURS OF MAN AND HORSE LABOR REQUIRED PER ACRE FOR INTERCROP WORK

	Man hours			Horse hours		
	Fallon	Fernley	Reno	Fallon	Fernley	Reno
Furrowing and other field work	1.2	2.5	2.8	2.4	4.3	4.9
Upkeep of equipment	1.1	1.1	1.4	.3	.1	.2
Upkeep of irrigation system	2.0	3.2	2.7	.7	1.1	.9
Overhead	.6	.8	.8	.3	.3	.4
Totals	4.9	7.6	7.7	3.7	5.8	6.4

IRRIGATING ALFALFA

The time required per acre to irrigate alfalfa depends upon the type of irrigation practiced, upon the head of water used, and the porosity of the soil. At Fallon where all alfalfa is irrigated by flooding about 40 per cent less time is required per acre than in the Fernley-Reno districts where furrow irrigation is used.

During the three years 1926, 1927 and 1928 the water supply was scant in the Fernley and Reno districts, and this may have had the effect of increasing the time required to irrigate. When the water supply is plentiful the land can be irrigated in less time than when the irrigation heads are small. The difference in the time required to irrigate by the flooding method and by the furrow method may, therefore, be due not so much to the system used as to the fact that there was a plentiful supply of water where the flooding system was used and a scant supply in the furrow irrigated districts. Yield per acre does not materially affect the time required to irrigate.

In the following table is shown the average time and the middle-class range required to irrigate for each cutting. In this middle-class range is included the time used by one-half of the farmers reporting closest to the median time. By this means the extremes, which are not typicals, are omitted. In securing the average, however, all the reports are used.

TABLE VII—TIME REQUIRED TO IRRIGATE ALFALFA

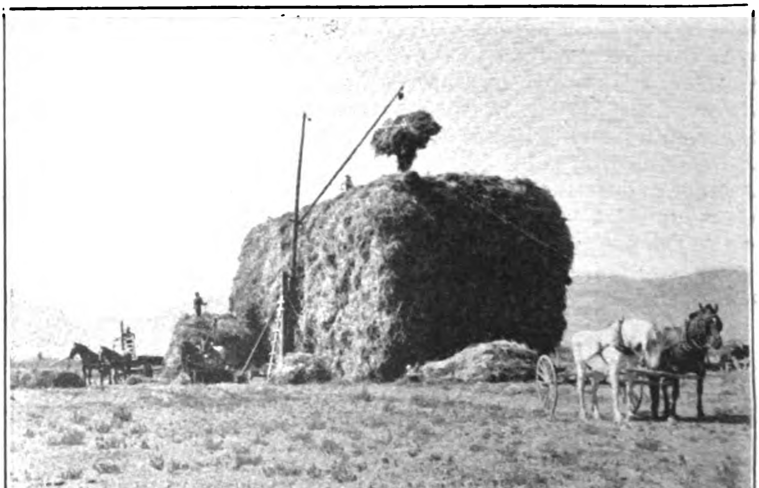
Locality	Cutting	Average hours	Median hours	Middle-class range hours
Fallon	First	1.7	1.6	1.2-2.2
	Second	1.4	1.3	.8-1.9
	Third	1.3	1.2	.7-1.6
	Totals three cuttings	4.4	4.1	
Fernley-Reno	First	3.8	3.8	2.5-4.3
	Second	1.8	1.5	.8-2.1
	Third	1.7	1.4	.9-2.6
	Totals three cuttings	7.3	6.7	

MOWING

The time required to mow alfalfa was determined from the records of 198 fields, representing 6,943 acres. The average time required to mow an acre was 1.24 hours (74 minutes). The middle-class range was

from 1 to 1.3 hours (60 to 78 minutes). The standard time for mowing may be taken at 1.2 hours. The horse labor in mowing is just double the man labor. There was no material difference in the time required to mow the first, second and third cuttings, nor is there any material

Field of Alfalfa Hay in Cock on a Farm Near Fallon.



Usual Method of Stacking Hay in Western Nevada, Showing Common Type of Derrick Used.

difference when the average of one year is compared with that of another.

RAKING AND BUNCHING

The labor requirement for raking and bunching alfalfa hay was determined from 170 separate rakings of individual fields, representing a total of 5,842 acres. Some of the farmers rake their fields without bunching the hay in the windrows, so it was necessary to separate the time for raking alone from the time required for raking and bunching.

For raking alone the median time required was .56 hours (34 minutes), with a middle-class range between .49 and .66 hours (29 to 40 minutes).

For raking and bunching the median time required was 1 hour, with a middle-class range between .88 and 1.12 hours (53 to 67 minutes). The time required to rake, bunch and rerake is exceedingly variable as no very uniform practice exists. The time required to bunch is of course affected by the yield.

There was no material difference in the time required to rake without bunching the first, second and third cuttings, but when the hay is raked and bunched less time is required for a light third crop than for either the first or second cuttings.

COCKING ALFALFA

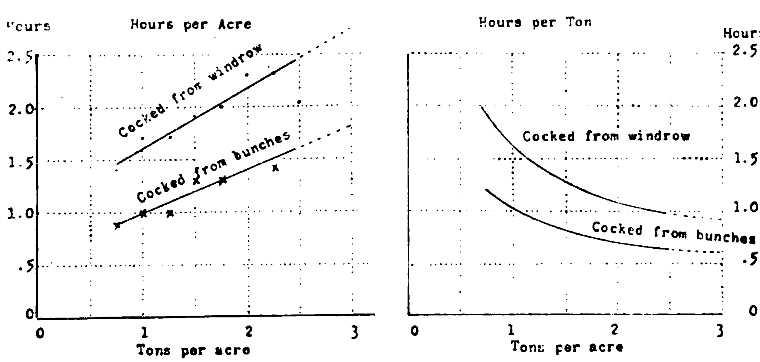
Cocking is performed by hand, either from the windrow without bunching or the rough bunches made by the rake are rounded up by hand. Some farmers do not cock the hay at all, but pitch from the windrow or rough bunches directly onto the wagons. When the hay is pitched by hand without cocking, the time of both men and teams in loading is somewhat increased, although the time required to cock the hay has been eliminated. When the hay is cocked soon after raking there is some improvement in quality, as less scattered hay is exposed directly to the action of the sun and wind.

The time required to cock hay varies with the yield per acre, as shown by Table VIII and by Chart V.

TABLE VIII—EFFECT OF YIELD PER ACRE ON TIME REQUIRED TO COCK FROM THE WINDROW AND FROM BUNCHED HAY

Yield per acre, tons	Hours per acre — From windrow	Hours per acre — From bunches
½	...	.7
¾	1.4	.9
1	1.7	1.0
1¼	1.7	1.0
1½	1.9	1.3
1¾	2.0	1.3
2	2.3	...
2¼	2.3	1.4
2½	2.0	..

V COCKING ALFALFA
Relation of Yield to Man Labor



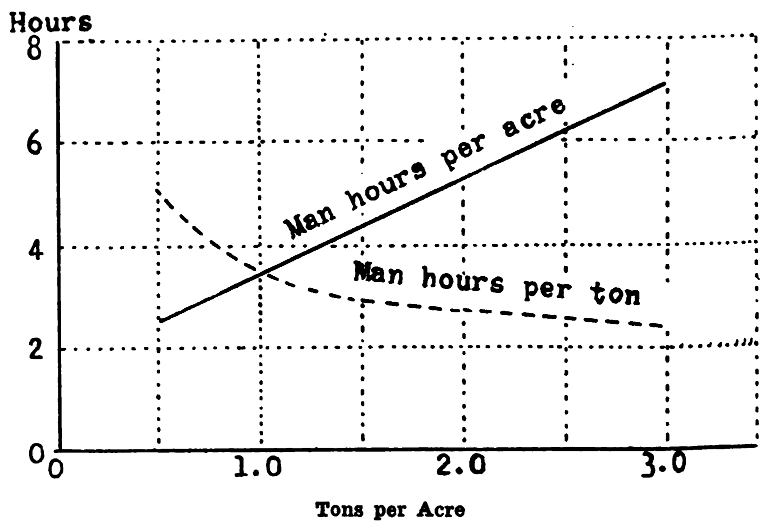
STACKING

Stacking hay is an operation that is materially influenced by yield, so that a statement of the average time required per acre has little significance unless the yield per acre is also given. By grouping all fields according to yield it has been possible to determine quite accurately the effect of yield on labor required per acre and per ton, as shown in Table IX and in Chart VI.

TABLE IX—EFFECT OF YIELD PER ACRE OF ALFALFA HAY ON THE LABOR USED IN STACKING (ONCE OVER)

Yield per acre, tons	Labor per acre		Labor per ton	
	Man hours	Horse hours	Man hours	Horse hours
½	2.8	3.2	5.6	6.4
¾	3.0	3.5	4.0	4.7
1	3.4	4.0	3.4	4.0
1¼	3.9	4.4	3.1	3.5
1½	4.2	4.6	2.8	3.1
1¾	4.4	4.8	2.5	2.8
2	5.0	5.5	2.5	2.8
2¼	5.8	6.1	2.6	2.7
2½	6.4	6.7	2.6	2.7
2¾	6.9	6.4	2.5	2.3

VI. STACKING ALFALFA—RELATION OF YIELD TO MAN LABOR



The time required per acre to stack each of the three cuttings is shown in Table X. In this table the average time and the middle-class range are shown. The difference in time per acre required to stack the first and second cuttings is very small, but the time required to stack the third cutting is reduced about 30 per cent as a result of the lower yield of the third cutting.

TABLE X—TIME REQUIRED PER ACRE TO STACK THE FIRST, SECOND AND THIRD CUTTINGS OF ALFALFA

	Cutting	Average hours	Middle-class range hours
Man labor	First	4.8	3.9–5.7
	Second	4.6	3.5–5.3
	Third	3.0	2.5–3.5
Horse labor	First	5.5	4.2–6.0
	Second	5.1	3.6–6.0
	Third	3.7	2.9–4.5

STANDARD LABOR REQUIREMENTS

It is often useful for a man or a company to be able to measure the efficiency of their work by some convenient standard. The output per worker is constantly checked by most of the larger manufacturing firms, and steps are taken to keep the efficiency of the men up to certain standards. The same holds true in many other lines of industry. In some of the States standard labor requirements for farm operations are being worked out, and it is now becoming possible for farmers to measure their own accomplishments by the standard of the average man.

In Table XI is given standard labor requirements for men and horses for the more important operations used in the production of alfalfa. If a farmer can perform any given operation in less than the standard time he is performing his work a little more efficiently than the average, at least in so far as the time used is concerned. The middle-class range is also given in this table. It indicates the range in time required to perform any operation by the middle half of the farmers who cooperated in this study.

TABLE XI—STANDARD LABOR REQUIREMENTS FOR FARM OPERATIONS NECESSARY IN THE PRODUCTION OF ALFALFA

Hours per Acre

	Standard		Middle-class range			
	Man hours	Horse hours	Man labor Low	Man labor High	Horse labor Low	Horse labor High
Plowing—						
Land not in alfalfa	5.0	15.0	4.5	6.6	14.3	23.8
Old alfalfa land	6.6	21.5	5.9	8.2	17.7	28.1
Harrowing—						
Spike tooth	.6	1.8				
Spring tooth	1.0	3.5				
Disk	1.0	4.0	.8	1.3	3.1	5.0
Furrowing	1.0	2.0				
Irrigating—						
By flooding, season	4.2	....	3.4	5.2		
By furrows, season	6.7	....	4.0	8.4		
Harvesting—						
Mowing	1.2	2.4	1.0	1.3	2.0	2.6
Raking	.5	1.0	.5	.7	1.0	1.3
Bunching with rake	.4	.8	.4	.5	.8	.9
Cocking from windrows	1.8	....	1.5	2.4		
Cocking from bunches	1.2	....	.9	1.3		
Stacking, first and second crop	4.6	4.8	3.6	5.3	4.0	5.9
Stacking, third crop	3.0	3.5	2.5	3.5	2.9	4.5

NOTE—The time given for each operation is once over, except for irrigating, for which the hours given represent the time required per year.

With the exception of the time for plowing, the standards given in Table XI correspond closely with the averages obtained in other States. The time used in plowing an acre of land seems to be higher in the area studied than in other sections. The normal amount of time to plow an acre in the middle west with 3 horses and a 16-inch plow is usually estimated at about 3½ hours. The average time used by the farmers who cooperated in this study is 5 hours when plowing land not in alfalfa, and 6.6 hours when plowing up old alfalfa. No satisfactory explanation can be given at present for the extra time required to plow an acre of land in western Nevada. Possibly the fact that the fields plowed usually were small had some effect in raising the time required.

INTERPRETATION OF RESULTS

The material just presented in this bulletin is of general interest to alfalfa growers because the cost requirements and labor requirements are presented for a characteristic alfalfa-producing area of Nevada. Many of these costs are difficult for an individual farmer to calculate for himself. This is particularly true of such items as enter into the sundry expenses. When a farmer does know his own costs these averages become valuable as standards by which he may measure his own efficiency. These studies may point the way to methods of lowering costs, for they show the reasons for variations in costs and suggest ways in which costs may be lowered.

What an individual may do in regard to lowering his cost of production is determined partly by natural conditions and to almost an equal extent by the individuality of the farmer. Lowering the cost has the same effect on profits as increasing the price received, but with this difference, that the lowering of costs is at least to some extent under the control of each individual farmer while the raising of prices is seldom within his control.

ADAPTATION OF RESULTS TO VARYING ECONOMIC CONDITIONS

The cost of growing an acre or a ton of alfalfa is extremely variable since cost depends upon so many variable factors. In the first place the methods employed by farmers is not at all uniform and there is quite a difference in efficiency in performing their work. When using identical equipment there is often a wide variation in the time required by different individuals to perform the same operation. In determining labor requirements it is necessary to express the results in terms of the "average" farmer. Although individuals vary in the time required to do a certain kind of work, the time required by the average individual shows remarkably little variation. The average time required to mow an acre of alfalfa practically always falls between one and one and one-quarter hours per acre, regardless of the place in which the investigation is made. In a bulletin just issued by the Oregon Experiment Station on Cost and Efficiency in Producing Alfalfa Hay (Oregon Station Bulletin 241), the average labor requirements for most operations are practically identical with those found in western Nevada. For practical purposes, it may be assumed that the average time required

for specific operations with similar equipment is a constant that does not materially change between one locality and another. The variation in the efficiency of individuals may be expressed by giving the middle-class range.

There are many physical or material factors in influencing cost of production that are easier to measure and adjust than is the individuality of the farmer. Some of these factors are productivity of the soil, size or types of machines used, size of fields, value of land, rate of interest, and value per hour of man and horse labor. The effect of all these variables can be measured and allowed for in making calculations of total costs. It is time wasted to present average costs of producing crops without making provision whereby corrections can be made for these factors that vary between localities and from year to year as economic conditions change.

With this objective in mind the charts on the following pages have been constructed. They make possible the adaptation of the data previously given to the conditions of other localities or to other economic conditions that may exist in the future. By utilizing these charts one may use any rate of man labor, any rate of horse labor, any interest rate, any land valuation or any yield per acre desired. The cost per ton under any combination of these items may be found by a simple process. Any change in prices of these factors can be accommodated within wide limits on these charts.

Farmers may use these charts as a standard in measuring their own efficiency. Since the charts are calculated from average costs, about one-half the farmers should be able to produce at a somewhat smaller cost while the others will produce their alfalfa at as great or somewhat greater cost than is indicated by the charts.

CALCULATION OF COST OF PRODUCTION OF ALFALFA UNDER VARYING ECONOMIC CONDITIONS

Throughout this bulletin fixed rates have been used for man labor, horse labor, land valuations, and interest rates, and average yields per acre for the various localities have been used. Whenever any of these values change, the cost of production changes so that the money costs so far given in the bulletin are of only local and temporary value, but the cost of production under any new set of price conditions can be quickly determined by using Charts VII and VIII.

Chart VII is used to calculate the cost per acre, without interest, at any labor rate of man or horse and with varying yields per acre when alfalfa is irrigated either by flooding or by furrows.

Chart VIII is used to calculate the effect of interest rate and value of investment per acre on the total cost.

The method of using these charts is explained on the pages facing each chart.

When only two cuttings of hay are put up, the cost of mowing, raking and stacking the third crop may be calculated from the table of standard requirements and this amount deducted from the results obtained by using the charts.

HOW TO USE CHART VII

Example—What is the cost of producing alfalfa by furrow irrigation with man labor at 33 cents per hour, horse labor at 9 cents, and the average yield per acre 4 tons?

1. Lay a ruler from 33 on scale A of the right-hand chart to 9 on scale B of the same chart, as shown by the dotted line, and read $23 on scale X. This is the cost per acre for a yield of four and one-quarter tons per acre.

2. To correct this cost for four tons per acre, lay the ruler from $23 on the scale X to 4 tons on the middle scale and read $22.50 on scale Y. This is the cost per acre without interest added. To find the cost with interest added turn to the next chart, after making corrections for sundry costs if any are needed.

To Correct for Variations in Sundry Costs

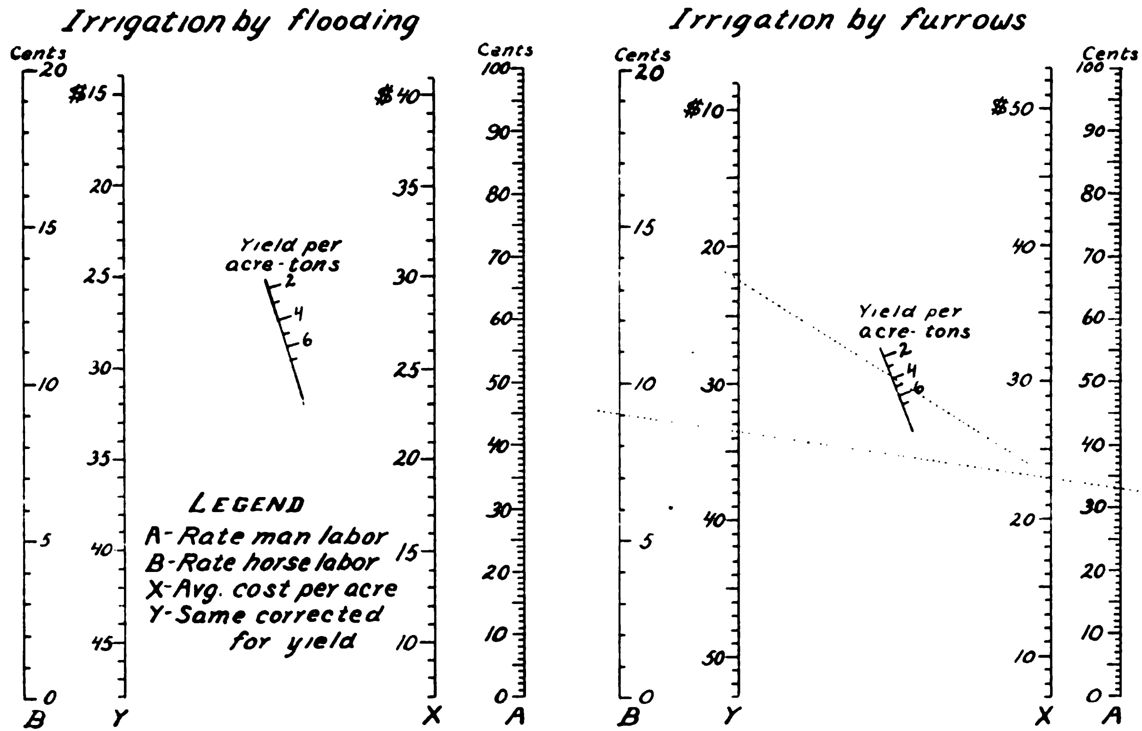
In this chart certain sundry costs are assumed that are chargeable against each acre of alfalfa. These costs are as follows:

Taxes	$1.50
Water	1.50
Irrigation system and equipment upkeep	2.00
Miscellaneous cash	.50
Overhead	1.50
Total	$7.00

Variations in these sundry costs can be made by simply adding or subtracting the correction from the final results.

If taxes in your locality are $1 instead of $1.50 per acre, and if water costs are only 75 cents an acre instead of $1.50, the total sundry costs would be reduced 50 cents for taxes and 75 cents for water, making a total reduction of $1.25. Merely subtract this amount from $22.50, which would leave $21.25 total cost per acre. Carry this result, $21.25, to the next chart to correct for interest on investment.

VII. EFFECT OF LABOR RATE AND YIELD ON COST PER ACRE

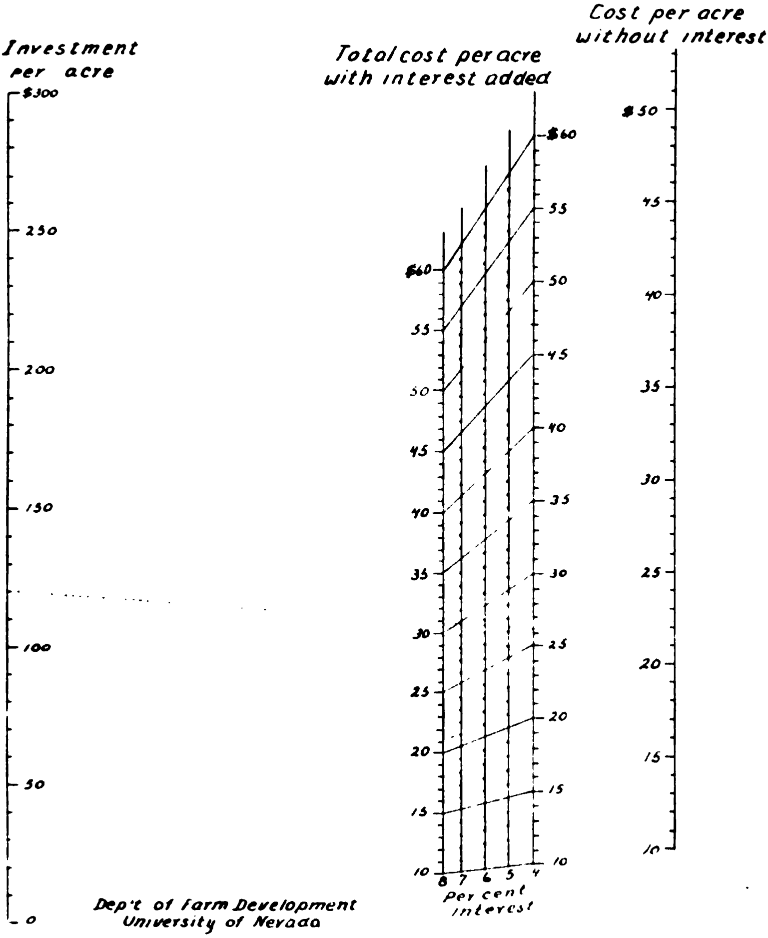


HOW TO USE CHART VIII

Example—From the example on the previous page it was found that the cost per acre under the conditions assumed was $21.25. What would be the cost with an investment per acre of $120 and interest charged at 5% ?

1. Lay the ruler from $21.25 on the right-hand scale to $120 on the left-hand scale and read the answer in the 5% column, which is $27.25. This value, $27.25, is the average cost per acre of producing alfalfa under the conditions assumed. To find the cost per ton simply divide $27.25 by the yield, which is $6.81 per ton.

VIII. Effect of Land Value on Cost of Production



OTHER METHODS OF UTILIZING RESULTS

1. Finding Value of Land

The charts may be used for the purpose of quickly determining on what valuation of land profits may be made or on what value the land will earn a fair rate of interest after all other expenses are met.

Example—What is the value of land for the raising of alfalfa hay under the following conditions? Man labor at 40c per hour; horse labor at 12c per hour; yield per acre, 5 tons; interest charge, 8%; average annual price for hay, $8 per ton; irrigation by furrowing.

Method—In Chart VII under Irrigation by Furrows it will be found that the cost per acre for a yield of 5 tons is $27. The amount received for 5 tons of hay at $8 would be $40 per acre. On Chart VIII place the ruler on 27 on the right-hand scale and across 40 on the 8% scale and read 162 on the left-hand scale. Land which would produce annually under these conditions would pay 8% interest on a valuation of $162 per acre.

This is the highest valuation of land on which interest could be paid at the assumed rate. The obvious value of this chart used in this way would be for the purpose of determining the actual value of land on the basis of its earning power.

2. Lowest Yield Possible Without Loss

Example—What is the lowest yield per acre that will permit the growing of alfalfa without loss, assuming the following conditions? Value of land, $150 per acre; interest rate, 6%; man labor at 40c; horse labor at 12c; average price per ton, $8; irrigation by flooding.

Method—By use of the charts make a table of per-acre costs and receipts for varying yields as follows:

	Cost without interest	Cost with interest	Value of crop at $8 per ton
2 tons per acre	$19.00	$28.00	$16.00
3 tons per acre	20.25	29.25	24.00
4 tons per acre	21.75	30.75	32.00
5 tons per acre	23.00	32.00	40.00

From this table it can be seen from inspection that a yield of 3 tons per acre will not meet expenses, while a 4-ton yield shows a profit of $1.25 per acre. The point at which receipts and expenses balance is therefore between 3 tons and 4 tons per acre, and can be found by further trial to be close to 3¾ tons per acre. Therefore, under the conditions given above alfalfa should yield 3¾ tons or more per acre to be profitable.

3. Return to Man Labor

The probable return to man labor may be calculated by means of the charts when the following factors are known: (1) The value of the land, (2) the rate of interest for which money can be borrowed, (3) the average yield per acre, and (4) the cost of horse labor.

Example—What will be the average return to man labor on furrow-irrigated land with the following values known? Value of land, $150; interest rate, 8%; average yield per acre, 5 tons; average price per ton, $8; horse labor per hour, 12c; land irrigated by furrows.

The average annual return for 5 tons of hay at $8 would be $40 per acre.

Method—(1) Place the ruler on $150 on the investment per acre scale, Chart VIII, and across $40 on the 8% line. Read approximately $28 on the right-hand scale. (2) Next turn to Chart VII and place the ruler on $28 on scale Y (irrigation by furrows chart) and across 5 tons on the yield per acre chart. Put the point of the pencil where the ruler crosses scale X. (3) Leaving the pencil in place lay the ruler from the pencil point on scale X to 12c on scale B and read 42 on scale A.

The probable return to man labor from this combination of prices will therefore be about 42 cents per hour.

The charts may also be used for determining the probable gain or loss from plowing up old alfalfa land and reseeding with a nurse crop by simply calculating the probable income each year for a series of years with both old and new seedings. The net cost of securing the new stand should, of course, be estimated and added to the annual cost of the new alfalfa after dividing by the average life of alfalfa stands in the section under consideration.

The economics of fertilizing can be easily calculated when the resulting increase in production is known.

Similar charts will soon be available for other crops than alfalfa, which will make possible the quick determination of the most profitable crops to grow as economic conditions change.

APPENDIX

MEASURING HAY IN STACKS

Some farmers find it difficult to calculate the number of tons of hay in stacks, and this is especially true for round stacks. A few charts have been added as an appendix to this bulletin by means of which the number of tons of hay in stacks can be calculated in a moment, after the dimensions have been found by measurement. The charts are accurate to the nearest ton, but cannot well be used for calculating to a small fraction of a ton. Since the usual formulas are usually not accurate within 5 or 10 per cent of the actual weight, there is really no increase in accuracy obtained when hay is measured and estimated to a fraction of a ton.

QUARTERMASTER'S RULE

To determine the tons of hay in long stacks it is necessary to measure the over, width and length. Measure the overthrow near each end and in the center and find the average.

The rule is to add the over to the width, divide by 4, multiply this result by itself, multiply by the length, and divide by the number of cubic feet in a ton, usually 512.

O=Over.
W=Width.
L=Length.

Formula: $\left(\frac{O+W}{4}\right)^2 \times \frac{L}{512} = \text{Tons}$

Example—Find the tons of hay in a stack of the following dimensions: Over, 66 ft.; width, 30 ft.; length, 47 ft.

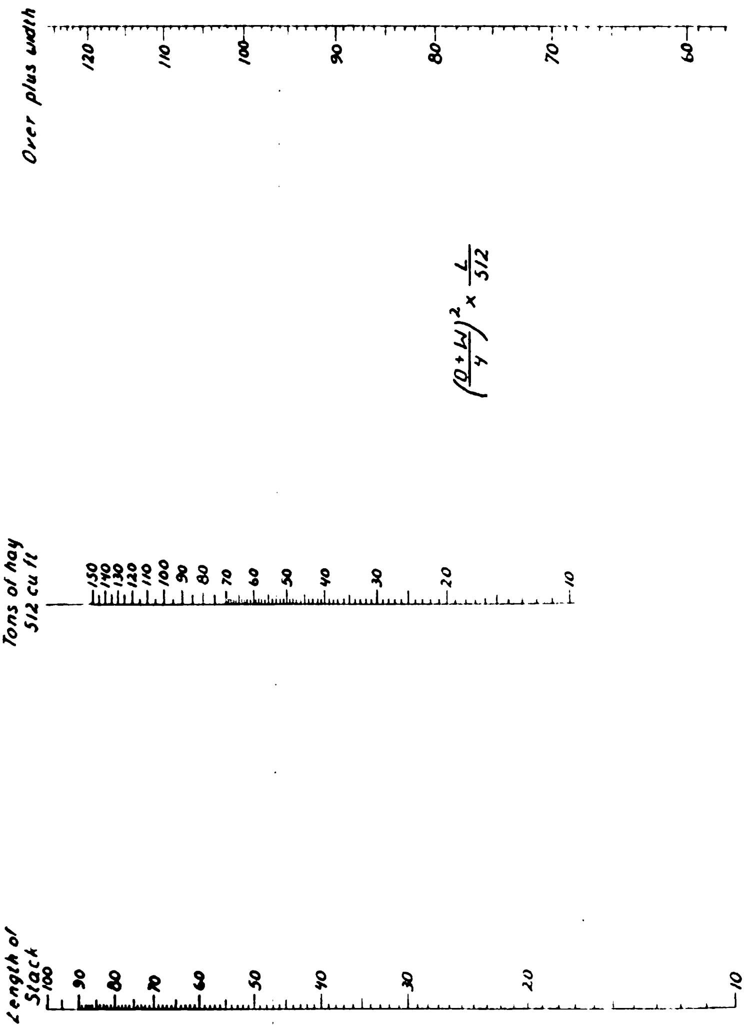
By Arithmetic—

$66 + 30 = 96$
$96 \div 4 = 24$
$24 \times 24 = 576$
$576 \times 47 = 27072$
$27072 \div 512 = 52.9$ tons.

By Chart—Lay a ruler from 96 on the right-hand scale to 47 on the left-hand scale of Chart IX, and read 53 tons on the center scale.

NOTE—If it is desired to use any number of cubic feet per ton other than 512 carry the answer 53 to Chart XI, and follow directions.

IX. HAY IN LONG STACKS
QUARTERMASTERS RULE



Round Stacks

To estimate the number of tons of hay in round stacks it is necessary to measure the circumference and the over. Measure the circumference midway between the ground and the bulge. In getting the overthrow, the tape should go over the highest part of the stack, and two measurements should be made at right angles to each other. The average of these two measurements may then be used as the true measure of the over.

The rule is: Add the over to the diameter, divide by 4, multiply this result by itself, then multiply by one-fourth the circumference, and divide by the number of cubic feet per ton, usually 512.

C=Circumference.
D=Diameter.
O=Over.

Formula: $\frac{C}{4}\times\left(\frac{O+D}{4}\right)^2\div 512=\text{Tons}$

Example—Find the tons of hay in a round stack of the following dimensions: Over, 85 ft.; circumference, 120 ft.

By Arithmetic—

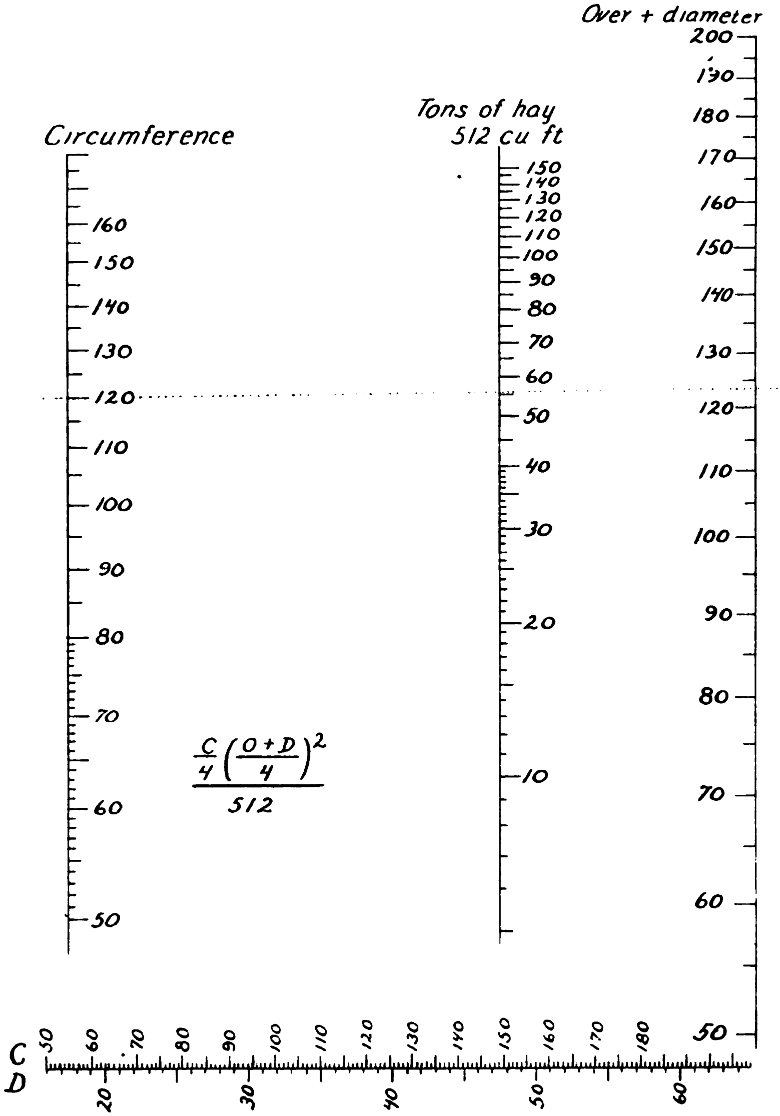
$$\frac{C}{4}=120\div 4=30$$
$$D=120\div 3.1416=38.2$$
$$O+D=85+38.2=123.2$$
$$\frac{O+D}{4}=123.2\div 4=30.8$$
$$\left(\frac{O+D}{4}\right)^2=30.8\times 30.8=948.64$$
$$\left(\frac{O+D}{4}\right)^2\times\frac{C}{4}=948.64\times 30=28459.2$$
$$28459.2\div 512=55.6 \text{ tons}$$

By Chart—To find the diameter, D, find the circumference 120 on scale C and note that the diameter is 38.2 feet. Add this to the over to get *over + diameter*, 85+38.2=123.2.

Lay a ruler from 123.2 on the right-hand scale to 120 on the left-hand scale, and read tons on the central scale which is slightly over 55 tons.

NOTE—If it is desired to use any other number of cubic feet per ton than 512, carry the answer 55.6 to Chart XI and follow directions.

X. HAY IN ROUND STACKS



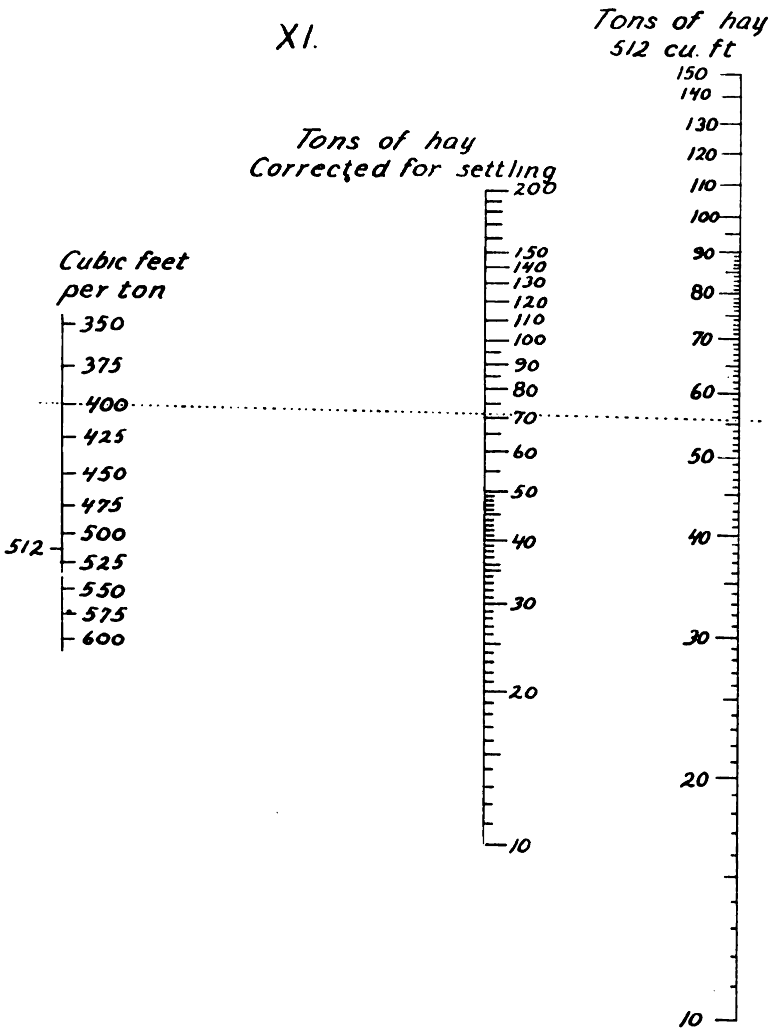
CORRECTION FOR NUMBER OF CUBIC FEET PER TON OF HAY

The number of cubic feet in a ton of hay depends upon the kind of hay, moisture content when stacked, precipitation since stacking, and length of time since stacking. In practice it is usual to take into consideration only the length of time stacked, and even for this there is no rule uniformly followed.

Charts IX and X give the number of tons in stacks when 512 cubic feet per ton is used. When it is desired to use any other number of cubic feet Chart XI is used to correct the answers obtained from Charts IX and X.

Example—In the example given for the round hay stack, Chart X. 55.6 tons were found when 512 cubic feet were used. How many tons in a stack of the same dimensions when 400 cubic feet are used?

Lay a ruler from 55.6 on the right-hand scale of Chart XI to 400 on the left-hand scale and read the corrected result, 71 tons on the center scale.


XI.
Tons of hay
512 cu. ft
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Tons of hay
Corrected for settling
200
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Cubic feet
per ton
350
375
400
425
450
475
500
512
525
550
575
600

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 118 RENO, NEVADA June, 1930

EFFICIENCY IN DAIRYING

This bulletin includes three separate papers on the subject of Dairy Efficiency which were originally published in mimeographed form in the monthly News Bulletin issued by this Department. The demand for these numbers indicated that it would be justifiable to publish them in permanent form so they would have a wider distribution. Only a few minor changes have been made from the original.

By
F. B. HEADLEY
Chief, Department of Farm Development
CRUZ VENSTROM
Assistant, Department of Farm Development

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE—JOE FARNSWORTH, SUPERINTENDENT
1930

1[76]

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

HON. G. F. TALBOT (1931)....Reno
HON. FRANK E. WILLIAMS (1933)....Goodsprings
HON. WALTER E. PRATT (1935)....Reno
HON. GEORGE S. BROWN (1937)....Reno
HON. GEORGE WINGFIELD (1939)....Reno

OFFICERS

WALTER E. CLARK, Ph.D....President of the University
CHARLES H. GORMAN....Comptroller
GEORGE H. TAYLOR....Secretary Emeritus
CAROLYN BECKWITH....Secretary

STAFF

SAMUEL B. DOTEN, M.A., Director....Entomology
CHARLES E. FLEMING, B.S.A....Range Management
EDWARD RECORDS, V.M.D....Veterinary Science
GEORGE HARDMAN, M.S....Irrigation
M. R. MILLER, M.S....Chemistry
LYMAN R. VAWTER, D.V.M....Associate in Veterinary Science
F. L. BIXBY, C.E....Collaborator in Irrigation Engineering
(Bureau of Public Roads, Irrigation Division, U. S. D. A.)
ROBERT STEWART, Ph.D....Soils Research
V. E. SPENCER, M.S....Associate Soils Research
CHESTER BRENNEN, B.S....Economist in Range Management
GRANT H. SMITH, JR., B.S....Assistant Range Economist
F. B. HEADLEY....Farm Development
CRUZ VENSTROM, B.S....Assistant in Farm Development
G. R. ADAMS, B.S....Fellow in Chemistry
ANDREW YOUNG....Assistant in Range Management
KARL W. NIEMANN, D.V.M....Assistant in Veterinary Science
MATILDA MARSHALL....Specialist in Farm Cost Studies
JEAN HUGHES....Secretary to Veterinary Science
MARTHA R. BRUCE....Illustrator and Secretary
GRACE COSTELLO....Librarian and Secretary to Director

I. EFFICIENCY IN DAIRYING

Dairying is one of the most important industries in the United States. In value of product it is second only to iron and steel. It is one of the few important agricultural enterprises that have consistently maintained a fairly satisfactory price index during the post-war period. If other agricultural commodities had been maintained on as satisfactory a basis as the products of the dairy industry, or at least that portion of the dairy industry that produces butter fat, there would have been less agitation for farm relief.

Although dairying is in a healthier condition than most of the other enterprises of the agricultural family, there is still a need of improvement. The average dairyman of Nevada is just about making wages and interest on investment; this means that the less efficient 50% of them are getting somewhat less than a satisfactory labor income. It is hardly to be expected that conditions could be permanently improved so that most of the dairymen would get a high labor income; green pastures are always so attractive that luxurious living conditions in any one field do not last long.

The United States continued to import dairy products until the latter part of 1929, but for nearly a decade our dairy production had come within one per cent of supplying our own requirements. Under these conditions any artificial stimulation of butter fat prices would probably result temporarily in an increased dairy production that would soon put this country on an export basis with resulting price fluctuations and a later downward trend in the industry.

There is another danger to the industry that might result from any temporary stimulation of butter prices. Every increase in the price of any product is usually followed by a decrease in the demand for that product and an increase in the demand for some substitute that will take its place. Raising the price of butter will increase the use of butter substitutes, but lowering the price after an increase will not bring back all the consumers who have become accustomed to the use of the substitute.

The available means of permanently improving the dairy industry are cooperative marketing and more efficient methods of production. These methods will not result in increasing cost of dairy products to consumer; they will put dairying on an efficiency basis founded on sound economic principles. Prices will be more fully stabilized and the quality of products standardized.

ECONOMIC HISTORY OF THE NEWLANDS IRRIGATION PROJECT, 1912-1929

INTRODUCTION

The Truckee-Carson Project was one of the first for which construction and development was authorized by Congress, in the Federal Reclamation Act of 1902. Public lands were opened by the United States to homestead entry in 1907, after completion of the Truckee canal which carries water from the Truckee River and empties it into the Carson River. The union of these two rivers that furnish the water supply of the project suggested the name Truckee-Carson Project, which was first adopted. The name was later changed to Newlands Project in honor of Francis G. Newlands, the author of the Reclamation Act.

Lahontan dam was completed in 1915. This dam conserves the waters of the Carson River and that part of the Truckee River which is carried to the reservoir through the Truckee canal. The Lahontan reservoir, which was thereby formed, is capable of storing 294,000 acre feet of water and made possible the conservation of much water that was previously lost, increased the area that could be safely brought under cultivation, and insured a dependable water supply to the lands below the dam. Even in the periods of lowest rainfall there has been ample water to produce maximum crops, but the bench lands above the reservoir have occasionally been somewhat short of water during the latter part of the irrigation season.

In 1912, the United States Reclamation Service began taking an annual census which included the number of acres irrigated, the number of live stock of each kind, and the acreage and yield of the various crops. The census is required by the Reclamation Bureau and has been continued since control of the project was assumed by the Truckee-Carson Irrigation District in 1926. The Department of Farm Development of the Nevada Agricultural Experiment Station entered into cooperation with the district and undertook to tabulate the results secured in 1929 and to correlate them with the census reports of previous years. All the expense of tabulation has been borne by this department.

It was intended by the Reclamation Bureau that the annual census reports should serve as a means of determining the progress of the development of the various Federal projects and they have undoubtedly been of great value from this standpoint, but it was believed by the authors that these census results for the Newlands Project, if carefully tabulated and published, would be of considerable interest and value to the business interests as well as to farmers of the project.

The value of economic studies of this kind is becoming generally recognized. They make it possible to study the business of agriculture of the county or project or community as if it were a single business concern, and to evaluate the strong and weak points of its make-up. With this information available, it should be possible for county agents,

the Farm Bureau and private individuals to work more effectively in the shaping of the agricultural policy of the district along the more profitable lines of development.

An analysis of this kind necessarily brings to light some less satisfactory lines of development which must be presented along with data that show real progress in other lines. It is the study of the more backward phases of the agriculture of the project that should make it possible to plan future development along sounder economic lines.

METHOD OF TAKING CENSUS

The farm census of the Newlands Project is taken by the ditch rider in each district in the fall of the year, generally in October or early November. When complete, the schedules from each farm are sent to the district office for compilation. When the tabulations have been completed the results are published in the local papers and the summaries are published by the Newlands Experiment Farm in the reports of that Station. No attempt to analyze the results for all years has previously been made. In 1929 the results were compiled as usual in the district office, but the expense of compilation was met by the Department of Farm Development.

In this bulletin the attempt is made to correlate the results of the 18 census summaries and to subject them to economic analysis in order that the farmers of the Newlands Project may obtain some additional benefit from the mass of data which has hitherto been available, but which remained practically unused. To these summaries has been added other information such as the freight movement of various commodities, purchases of cream by creameries and other similar facts of economic importance.

The average United States Farm Price, where used in the tables, has been obtained from the Yearbook or from Crops and Markets issued by the United States Department of Agriculture.

TOTAL AREA IRRIGATED AND CULTIVATED

When the first census was taken in 1912, the total irrigable area under water contract was found to be 55,000 acres. This area increased slowly until 1919, when settlement of the Carson Lake and Soda Lake Districts caused a sudden rise to a total of nearly 70,000 acres of irrigable land owned within the project. In 1929, the irrigable area had increased to 85,000 acres with the inclusion of the community pasture.

The decline which took place between 1922 and 1927 was due to two principal causes. The high price levels between 1916 and 1920 induced the settlement of many new units of relatively low productivity. When the price recession came in 1921 some of these units were abandoned. High water tables further added to the difficulty of farming all marginal lands, and caused the abandonment of a small part of the irrigable area. Recent drainage work is now checking further reduction of the irrigable area because of high water tables, and some previously unproductive land has been reclaimed.

The area actually irrigated is a better index of the growth of the project than the irrigable area. The irrigated area started at about 36,500 acres in 1912, and has increased steadily, with only minor fluctuations, up to the present time. The total is now reported to be

47,300 acres irrigated, with the community pasture omitted, or 54,040 acres when it is included. There was a decline in the irrigated area of about 2,000 acres as a result of the financial depression following the war, but since 1925 this loss has been more than made up.

The cultivated area is a better index of the development of the project than is either the irrigable or irrigated area, for it indicates the amount of land that is improved sufficiently to produce crops. In 1912, the cultivated area amounted to 22,868 acres which has continued to increase quite steadily, and with only minor fluctuations up to the present time, when it stands at nearly 40,000 acres, an average increase of about 1,000 acres per year.

TABLE I

Acres Irrigable, Acres Irrigated, and Acres in Cultivated Crops on the Newlands Project, 1912-1929

Year	Acres irrigable under water right contracts	Acres irrigated	Acres of cultivated area
1912	54,937	36,620	22,868
1913	56,950	43,075	27,884
1914	56,955	39,516	27,261
1915	58,620	40,295	27,058
1916	62,284	39,449	27,086
1917	60,758	40,892	29,421
1918	60,946	42,811	33,234
1919	62,105	44,824	35,219
1920	69,310	45,611	36,722
1921	70,650	46,143	36,753
1922	71,220	44,963	36,151
1923	68,409	44,866	35,781
1924	67,464	44,280	37,933
1925	65,381	42,453	37,936
1926	65,277	45,459	39,598
1927	65,277	49,255	40,826
1928	64,114	49,970	40,603
1929	66,649*	47,301†	39,531

*When the irrigable portion of the community pasture is included this figure is increased to 85,825.

†When the irrigated portion of the community pasture is included this figure is increased to 54,040 acres.

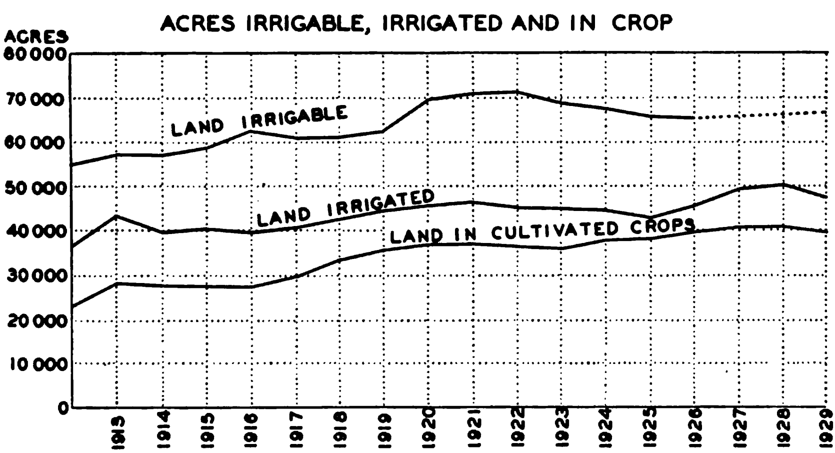


Chart 1. Graph showing contract area irrigable, area irrigated, and area cultivated from 1912 to 1929, inclusive.

ALFALFA

The area in alfalfa rose steadily from 12,912 acres in 1912 to 29,943 in 1922. Since that time the area has remained practically constant. About 3,200 acres were seeded annually to new alfalfa during the period of expanding alfalfa acreage, but the annual increase in total alfalfa acreage averaged only 1,650 acres. This indicated that about 1,550 acres of land previously in alfalfa were put to other use each year. During 1928 about 3,000 acres new alfalfa were seeded without a resulting increase in total acreage, indicating that an equal area of old alfalfa was utilized for other purposes.

TABLE II

Area and Production of Alfalfa, 1912-1929

Year	Old alfalfa Acres	New alfalfa Acres	Yield per acre Tons	Alfalfa produced Tons
1912	12,912	3,319	2.60	33,595
1913	18,960	4,523	3.23	45,122
1914	18,212	3,344	3.29	59,873
1915	18,273	2,070	2.93	53,496
1916	19,541	1,904	3.16	61,756
1917	20,860	2,141	3.57	72,769
1918	21,542	3,725	3.59	77,442
1919	24,188	3,854	3.84	92,850
1920	26,540	4,254	3.50	92,819
1921	28,287	2,923	3.38	95,561
1922	29,943	1,168	3.20	95,850
1923	28,210	1,907	3.00	84,541
1924	30,652	1,166	3.01	92,500
1925	28,183	2,459	3.23	90,997
1926	28,961	2,196	3.37	97,581
1927	29,849	1,977	2.88	86,114
1928	29,054	3,012	3.31	96,167
1929	28,922	3,169	3.16	91,446

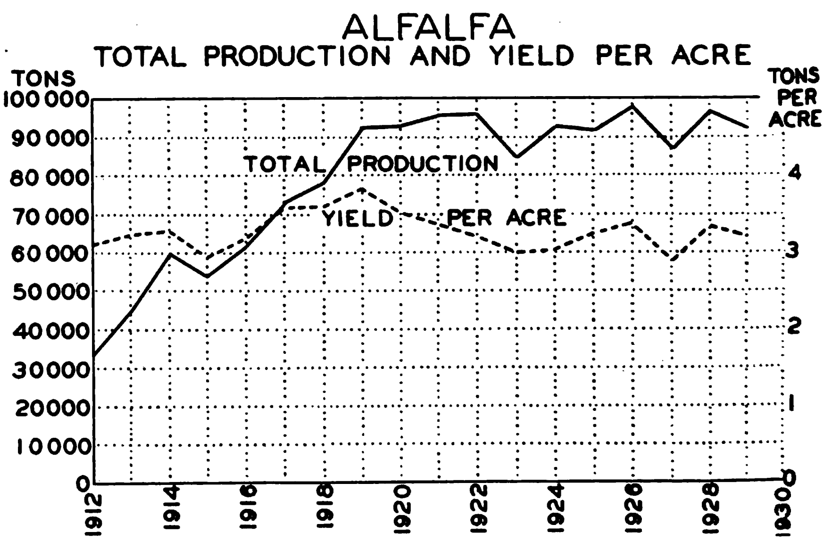


Chart 2. Graph showing total production and yield per acre of alfalfa on the Newlands Project from 1912 to 1929, inclusive. Total production trend has remained practically constant since 1919.

The total amount of alfalfa produced on the project increased faster than the area in alfalfa until 1919 when an average yield of 3.84 tons

per acre was obtained. Since 1919 the yield per acre for all farms on the project has remained slightly above or below 3¼ tons. Since 1912 there have been three exceptional depressions in yield as indicated by sharp drops in the production curve shown in Chart 2. In the spring of 1915 a heavy frost severely damaged the first crop. In 1923 a combination of aphis and locusts reduced the yield of the first crop, and again in 1927 the aphis, assisted by a cold, backward spring, caused another decided drop in the production curve.

Since the deflation year of 1920 the area in old alfalfa has averaged 29,118 acres, and there has been but little variation in area. New seedings have varied from 1,163 to over 3,000 acres per year. The area of old alfalfa plowed up and of new alfalfa put in is influenced by the current prices of cash crops.

New seedings average 2,219 acres yearly since 1920. This is 7.6% of the average area in old alfalfa. It means that one acre must be seeded each year to every 13 acres in old alfalfa in order to maintain the old alfalfa acreage.

New seedings for the period 1912–1920 average 3,237 acres yearly. Old alfalfa increased from 12,912 acres in 1912 to 26,540 acres in 1920. This is an average annual increase of 1,704 acres per year for 8 years, or an average annual replacement of 8.7%.

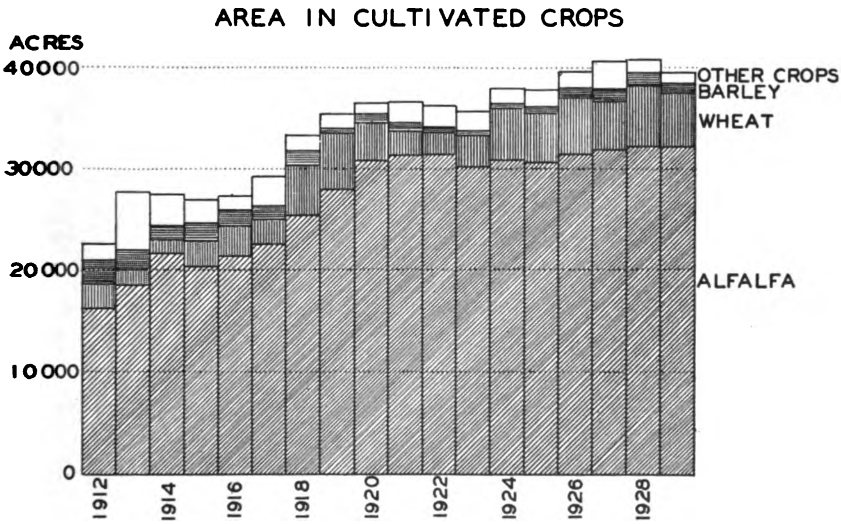


Chart 3. Graph showing total area in cultivated crops on the Newlands Project from 1912 to 1929, inclusive. Note that alfalfa occupies more than three-fourths of the total area. Irrigated native grass pasture is not included in this chart.

GRAIN AND CORN

On many of the smaller farms of the project very little grain is produced, but grain is the primary crop on some of the farms in the Island and Stillwater sections of the project. It is used in all parts of the project as a nurse crop to alfalfa and frequently as an intermediate crop after old alfalfa has been plowed up.

In the earlier years of the project wheat and barley were planted in about equal amounts, but during the past decade wheat has become

much the more important crop of the two. The position occupied by wheat and barley in the agriculture of the project may be seen graphically presented in Chart 3.

The production of oats on the project has been practically discontinued since the replacement of horses by motor trucks in freighting to mining camps. The area in oats has not exceeded 72 acres since 1916.

Corn was not separately reported in the annual census of the project until 1922. Since that time the area in corn has fluctuated between the extreme limits of 160 and 424 acres, the average being 302 acres.

TABLE III

Area and Yield of Wheat, Barley and Oats on the Newlands Project, 1912-1929

	Wheat			Barley			Oats		
Year	Acres	Tons	Tons per acre	Acres	Tons	Tons per acre	Acres	Tons	Tons per acre
1912	2,484	1,222	.49	2,259	1,790	.79	399	270	.68
1913	1,590	910	.56	1,880	1,040	.56	283	164	.58
1914	1,446	874	.60	1,329	750	.56	417	288	.69
1915	2,582	1,625	.63	1,733	1,190	.69	428	230	.54
1916	2,861	1,730	.60	1,658	1,250	.75	107	73	.68
1917	2,532	1,295	.51	1,116	645	.58	27	15	.56
1918	5,024	2,965	.59	1,374	850	.62	44	29	.66
1919	5,423	2,495	.46	519	262	.50	31	15	.48
1920	3,586	2,745	.77	769	540	.70	68	54	.78
1921	2,443	2,006	.82	732	469	.64	60	48	.80
1922	2,410	1,510	.62	437	236	.54	72	30	.42
1923	3,116	2,115	.67	451	396	.88	70	45	.64
1924	4,081	2,690	.66	297	208	.70	62	62	1.00
1925	4,670	3,039	.65	760	528	.70	55	33	.60
1926	5,836	3,842	.66	920	523	.57	28	11	.39
1927	4,829	3,386	.70	1,209	806	.67			
1928	5,715	4,185	.73	1,615	1,103	.68			
1929	5,285	3,715	.70	1,031	653	.64			

At the present time the production of grain and corn for feed is not equal to the feed and seed requirements of the project. Importation of feeds into the project totaled 78 carloads in the period from July 1, 1928, to June 30, 1929, and 60 carloads from July 1, 1929, to June 30, 1930. The net imports of the several kinds of feed for the 1928 and 1929 seasons are given in Table IV.

TABLE IV

Net Imports of Feeds in Carloads, Seasons of 1928 and 1929*

	July, 1928, to June, 1929	July, 1929, to June, 1930
Wheat	1	0
Corn	37	18
Barley	7	8
Mixed feed	33	34

*The information in this table was supplied through the courtesy of the Agent of the Southern Pacific Company in Reno.

Wheat imports are negligible at the present time. Though the production of wheat fell off 470 tons in 1929 from the 1928 production, the demand fell off also because of the decrease in both chickens and turkeys. Mixed feeds and barley imports were practically unchanged in 1929, but corn imports were cut in half, probably due to the decrease of 10,000 turkeys and the lessened demand for fattening corn.

POTATOES

The potato acreage on the Newlands Project has been strongly influenced by the average United States farm price. The average United

States farm price for the 18 years, 1912 to 1929, inclusive, was $33.60 per ton. The average potato prices each year are based on the seasonal price beginning in September of the crop year and ending in May.

The average annual area planted to potatoes on the Newlands Project during the same 18-year period was 342 acres per year. The smallest area reported was 101 acres in 1929, and the greatest area was 870 acres in 1922.

TABLE V

Potato Acreage, Production and Average United States Farm Price, 1912-1929

Year	Acres	Production Tons	Average price per ton*
1912	483	1,969	$18.53
1913	416	894	23.53
1914	288	714	19.33
1915	196	754	23.60
1916	177	882	55.43
1917	322	1,693	40.83
1918	334	1,525	41.87
1919	152	731	74.60
1920	354	1,104	43.83
1921	484	2,792	40.43
1922	870	4,460	24.63
1923	659	3,230	31.40
1924	273	679	25.50
1925	152	616	61.66
1926	249	1,184	46.93
1927	542	2,248	36.13
1928	111	418	20.43
1929	101	455	45.23†

*This price from July of the given year to the end of the following June. Taken from Yearbook of the United States Department of Agriculture.

†Preliminary.

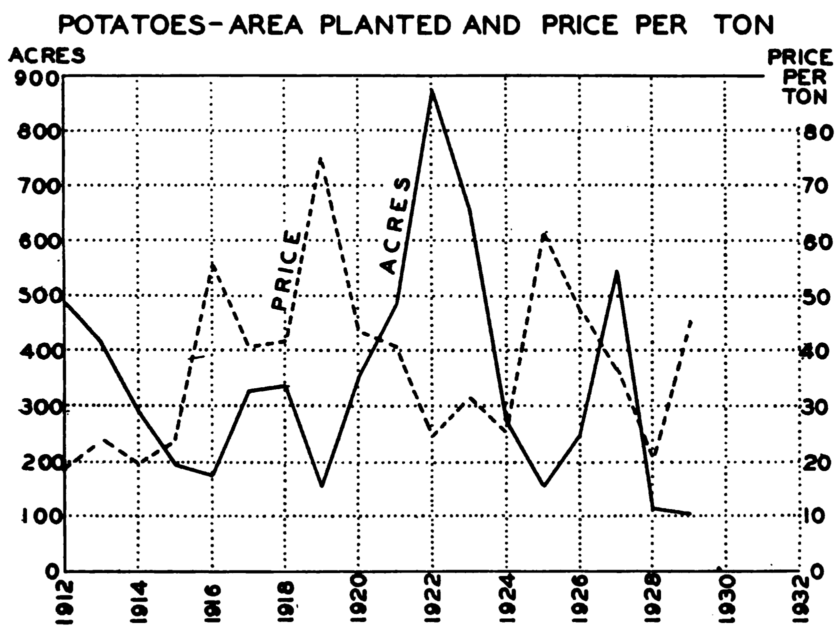


Chart 4. Area planted annually to potatoes contrasted with the U. S. price of potatoes on farms. Note that during years of high prices few potatoes were planted while the years of low prices are associated with large potato plantings.

The relation of area planted to the price is clearly seen in Chart 4. It will be noted that, with few exceptions, the largest acreage is associated with low price and low acreage with high price. In other words, the judgment of the growers in attempting to adjust their acreage to the price was wrong a large part of the time.

Instead of receiving the average price of $33.60 per ton, the potato growers guessed wrong as to the price of the next crop more than one-half the time and succeeded in getting a weighted average of only $30.20. If they had been able to estimate correctly the trend of the future market, more than one-half the time the weighted average price received would have exceeded $33.60.

CANTALOUPES

Canteloupes became sufficiently important to be included in the annual census for the first time in 1921, when a total area of 129 acres was reported. The area was expanded to over 500 acres in 1924 and 1925. The cantaloupe association met with marketing difficulties and disbanded, but the area has remained between 220 and 320 acres in recent years. The production of this crop is confined to relatively few growers who have been able to obtain a fairly dependable market outlet. The weighted average yield of cantaloupes on the Newlands Project is 144 crates per acre, while the weighted average yield of late cantaloupes in the United States is 148 crates per acre.

TABLE VI

Area in Cantaloupes on the Newlands Project, 1921-1929

Year	Acres	Production: Total crates	Production: Crates per acre
1921	129		
1922	336	59,610	177
1923	350	34,913	100
1924	532	79,531	149
1925	510	83,417	164
1926	335	48,485	144
1927	261	30,972	119
1928	221	35,507	161
1929	318	39,708	124

THE DAIRY INDUSTRY

The number of dairy cows on the Newlands Project has been recorded since 1914. The record of other dairy cattle begins at later dates. The available figures are given in Table VII.

In general, there has been a steady growth of the dairy industry. There was a decline in numbers in 1918 and 1919 which resulted from the high prices for hay and grain received during the war period. From 1920 to 1927 there was again a steady and rapid growth of the dairy industry, but in 1928 and 1929 there were fewer cows on the project than in 1927. This slight depression resulted from the active demand for dairy cows in southern California. It is estimated that shipments to the Los Angeles area were as follows: 700 head in 1927, 1,917 head in 1928, and about 1,000 head in 1929.

The number of heifers has been recorded since 1922. The proportion of heifers to cows on hand in the fall has steadily increased from 44.5% in 1922 to 68% in 1928 and 1929. This is explained by the shift of the

dairy cow shipments from an import to an export basis. In 1922 the Newlands Project was still shipping in cows to feed up its surplus hay. Consequently the proportion of heifers to cows was much lower than during the last two years when large numbers of cows were exported, leaving a greater proportion of heifers.

In bulls the trend is toward fewer grade animals and more registered. In 1929 the records show a total of 143 grade and 191 registered bulls.

TABLE VII

Number of Dairy Cattle by Classes, Newlands Project, 1914-1929

Year	Cows	Heifers	Grade bulls	Registered bulls
1914	1,503			
1915	2,433			
1916	2,537			
1917	2,044			
1918	1,895			
1919	1,850			
1920	2,072			
1921	3,597			
1922	3,457	1,534	......	97
1923	4,221	2,386	......	131
1924	4,712	2,654	147	160
1925	4,932	2,864	190	198
1926	5,341	3,182	172	212
1927	5,486	3,523	159	189
1928	4,890	3,315	159	187
1929	4,911	3,338	143	191

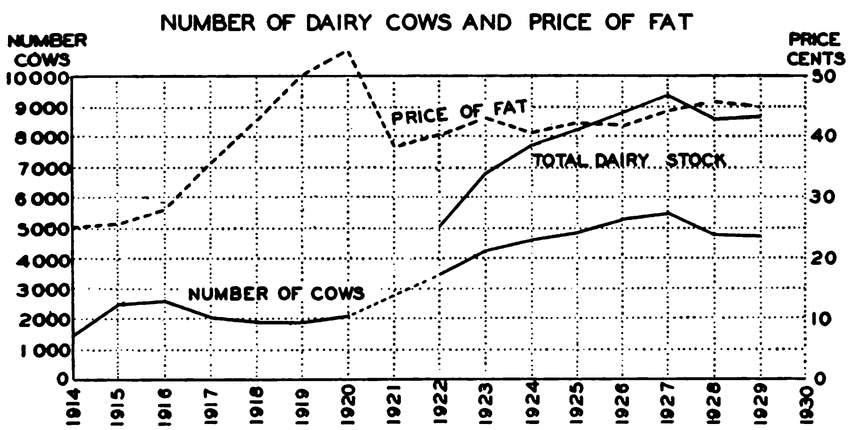


Chart 5. Graph showing the number of cows on the Newlands Project and the average U. S. farm price of butterfat for 1914 to 1929.

Of the 601 farms on the project in 1929, only 455 reported possession of one or more dairy cows. It would appear from this that 24% of the farms of the project are without any dairy cows.

In Table VIII the farms are grouped according to the size of the herds. About one-half the farms on the project have less than 6 cows per herd. More than half the cows of the project are on farms having from 6 to 20 cows per herd.

More cows are found in the group indicating a herd size ranging from 11 to 15 cows than in any other size of group. Only 15 herds in the project contained more than 30 cows in 1929.

TABLE VIII

Dairy Cows on Newlands Project, 1929; Dairy Heifers not Included

Size of herd Cows	Average number of cows per herd	Number of herds Total	Number of cows Total	Number of cows Per Cent of Total
0	0	146	0	0
1– 5	2.6	161	421	8.7
6–10	8.1	117	948	19.6
11–15	12.8	82	1,053	21.8
16–20	18.4	45	829	17.1
21–25	23.0	16	367	7.6
26–30	29.6	19	561	11.6
31–35	34.0	6	205	4.2
36–40	38.7	3	116	2.4
41–50	47.0	5	235	4.9
51–up	102.0	1	102	2.1
Totals	8.0	601	4,837*	100.0

*74 cows on the Indian Reservation and on the Experiment Farm were omitted from the above table which makes a complete total of 4,911 cows.

Average Production per Cow

The amount of butterfat sold from farms of the project in 1929, as reported in the project census, was 995,133 pounds. The combined purchases reported by five creameries, which handled over 99% of all the cream sold, amounted to 1,094,096 pounds. The estimates made by the farmers were about 9% less than the amount of butterfat actually sold.

The actual number of pounds of butterfat produced per cow is always of interest, as it serves as an index of the efficiency of the cows of the project. The pounds of butterfat produced divided by the average number of cows in 1929 (4,900) indicates average sales per cow of 223 pounds. This is not the total amount of butterfat produced per cow, as some is always used on the table and for feeding live stock. The amount so used varies widely on different farms, but in the cost of production studies conducted by this department it was found that the average amount so used was about 8% of the total production. If this figure be accepted, then 223 pounds per cow represents 92% of the total amount produced, which would be 242 pounds.

On farms having five cows or less, the home consumption of butter will exceed 8% of the total amount produced, and for this reason it is probable that the average total production per cow slightly exceeds 242 pounds. This is an excellent showing in view of the fact that this production is obtained practically on roughage crops alone, since almost no grain is fed to dairy cows on the Newlands Project.

Other Cattle

The number of other cattle reported in the annual census has shown wide fluctuations. Previous to 1922 the number of cattle was divided into only two classes, milking cows and all other cattle. Since 1922 the number of dairy heifers and dairy bulls has been reported separately. The number on hand at the time the project census is taken does not always truly represent the number coming in for fall or winter feeding. The time when the beef cattle are brought in for winter feeding varies widely according to season, since the weather and range conditions influence the time they may be kept on the open range. However, the general trend may be seen by the number reported in Table IX and as shown in Chart 6.

The number of cattle other than dairy cows reported on farms of the Newlands Project each year is as follows:

TABLE IX

Number of Other Cattle on Farms of the Newlands Project, 1914-1929

Year	Number	Year	Number: Beef	Number: Heifers and bulls	Number: Total
1914	4,540	1922	4,601	1,631	6,232
1915	5,957	1923	4,266	2,517	6,783
1916	7,802	1924	4,889	2,961	7,850
1917	7,581	1925	4,663	3,252	7,915
1918	8,839	1926	6,052	3,566	9,618
1919	6,778	1927	2,802	3,871	6,673
1920	7,428	1928	3,148	3,661	6,809
1921	6,732	1929	2,909	3,672	6,581

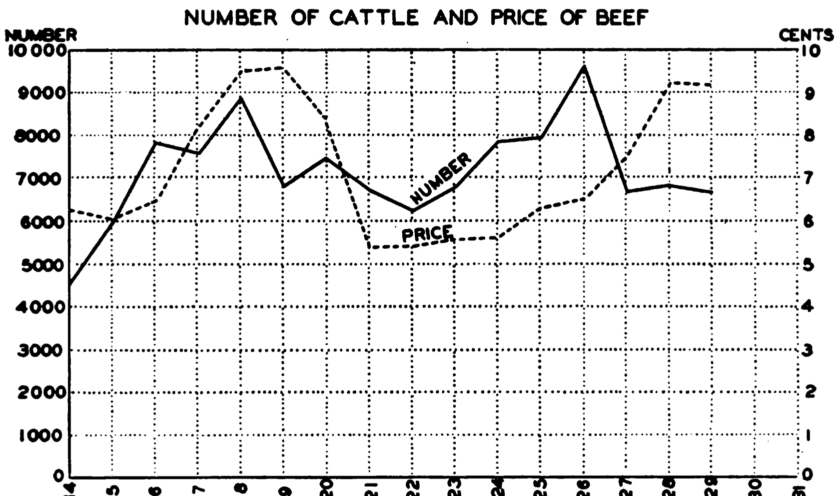


Chart 6. Chart showing the annual number of cattle on farms of the Newlands Project and the average U. S. farm price of beef. The numbers include beef animals, dairy heifers and bulls. The number of dairy heifers was not obtained separately until 1922.

SWINE

The production of hogs on the Newlands Project is not an important enterprise at the present time. Only 2,500 hogs were counted in the project census in 1929, while the average number for the past 16 years was 3,050. In 1916 the number on the project exceeded 6,000, but dropped off to less than 2,000 in 1921. The number of hogs reported on the project in the annual district census from 1914 to 1929, together with the average United States price on the farm, is given in Table X and is shown graphically in Chart 7.

TABLE X

Number of Hogs on the Newlands Project from 1914 to 1929, and the Average Chicago Price Each Year

Year	Number	Average price per lb. Cents
1914	3,515	8.3
1915	4,386	7.1
1916	6,092	9.6
1917	3,170	15.1
1918	3,343	17.5
1919	3,048	17.9
1920	2,211	13.9
1921	1,793	8.5
1922	3,214	9.2
1923	2,975	9.6
1924	2,296	8.1
1925	1,972	11.8
1926	2,265	12.3
1927	3,446	10.0
1928	2,598	9.2
1929	2,500	9.5

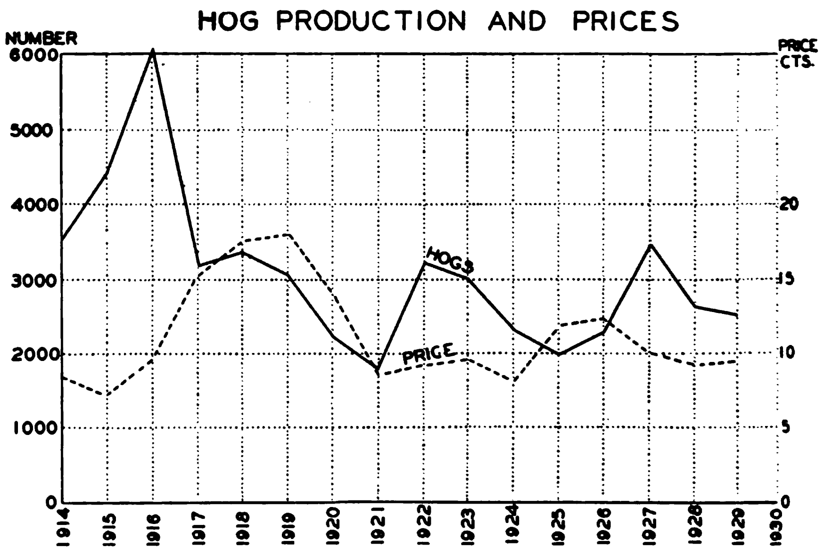


Chart 7. Graph showing number of hogs on the Newlands Project and the average Chicago price from 1914 to 1929. From U. S. D. A. Yearbook.

SHEEP

The number of sheep on the Newlands Project in 1929 was 12,100. The number reported when the census is taken may not give a true representation of the number raised and fed by the project farmers during the year. The census is taken at a time when sheep are usually being brought in from the ranges for winter feeding, and the numbers reported represent the number on hand when the census is taken. However, the report probably represents in a general way the trend of the numbers being fed.

The number of sheep and the average United States price of wool and lambs are given in Table XI and shown graphically in Chart 8. When the fluctuations are disregarded it will be seen from the chart

that there has been a steady increase in the number of sheep on the project since 1914. It is interesting to note on the chart that up to 1924 the number of sheep was low during periods of high prices and high during periods of low prices.

No record is available of the number of sheep brought into the project by nonresident sheep men for fall pasture and winter feeding on alfalfa hay.

Only 98 farmers out of 601 had sheep, but 57 per cent of the sheep were in the hands of seven farmers who had flocks exceeding 500 head. About 27 per cent of the sheep were in flocks ranging in size between 100 and 500 head, leaving only 16 per cent in small farm flocks of less than 100 head.

There appears to be a direct relationship between the size of the farm and the number of sheep. More than half the sheep on the project are on eleven farms having more than 160 acres of irrigated land per farm.

TABLE XI

Number of Sheep on Farms in the Newlands Project and the Average U. S. Farm Price of Sheep, Lambs and Wool from 1914 to 1929

Year	Number	Average U. S. Price — Sheep Dollars	Lambs Dollars	Wool Cents
1914	1,981	4.79	6.49	17.7
1915	4,710	5.27	7.38	22.8
1916	5,452	6.29	9.50	27.9
1917	3,346	9.45	13.60	47.8
1918	3,560	10.95	13.65	57.9
1919	3,347	9.63	13.05	50.3
1920	4,611	8.51	9.41	39.1
1921	7,707	4.65	7.83	16.4
1922	7,961	5.96	10.30	29.8
1923	7,286	6.65	10.54	38.9
1924	4,624	6.81	11.45	36.9
1925	12,807	7.70	11.98	38.5
1926	7,930	7.43	11.86	32.5
1927	7,230	7.26	11.76	30.7
1928	9,481	7.68	12.31	36.7
1929	12,100	7.55	10.65	30.9

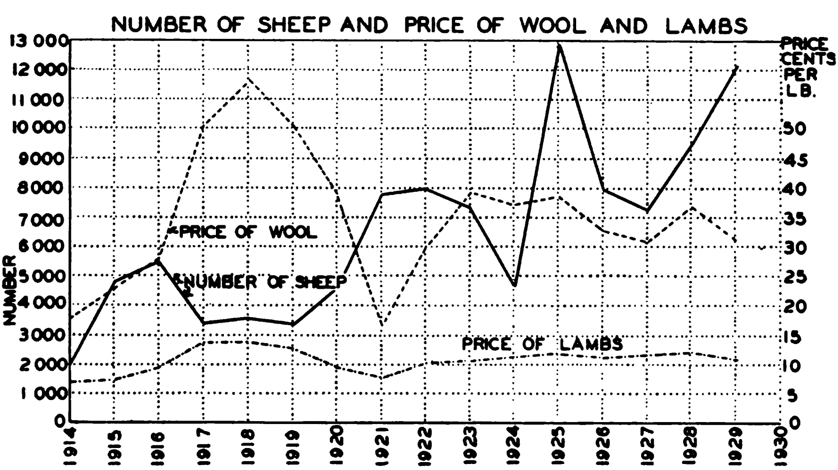


Chart 8. Graph showing number of sheep on the Newlands Project and the U. S. average farm price of wool, sheep and lambs.

TURKEYS

Turkey production in the Newlands Project was at first stimulated by the World War, but after the entry of the United States into the war the number of turkeys declined until 1919 when only 3,442 were reported. After that date the number on the project increased to 27,254 in 1923, dropped to 20,429 in 1925, and again increased to 57,594 in 1928. The lower prices received in 1928 caused another reduction in numbers the following year, when 46,840 were reported.

TABLE XII

Number of Turkeys on the Newlands Project, 1914-1929, and the United States Farm Price

Year	Number of turkeys	U. S. farm price Cents	Approximate Fallon price for No. 1 turkeys Cents
1914	6,972	14.4	
1915	12,000	15.3	
1916	15,289	19.2	
1917	9,042	22.3	
1918	4,746	26.7	
1919	3,442	30.5	
1920	3,624	32.6	
1921	4,834	30.5	
1922	12,100	30.5	
1923	27,254	25.2	
1924	22,415	25.4	
1925	20,429	30.4	
1926	30,613	31.4	51
1927	47,898	31.0	46
1928	57,594	30.0	38
1929	46,840	24.8	34

U. S. Farm price taken from Crops and Markets issued by the U. S. Department of Agriculture. The price shown is the average each year for the months of November, December and January.

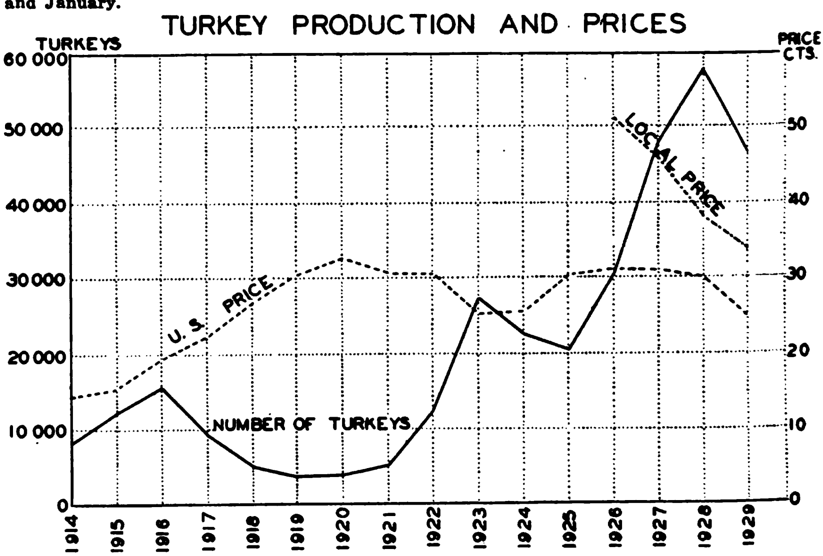


Chart 9. Graph showing the number of turkeys on the Newlands Project and the U. S. average farm price from 1914 to 1929.

The number of turkeys on the Newlands Project each year from 1914 to 1929 is shown in Table XII and Chart 9, together with the United States average farm price. It seems that from 1916 to 1919 the prices of other farm commodities were so high that the number of turkeys produced steadily declined in spite of rising prices. After the drastic fall in prices of most farm products in 1920 and 1921, the number of turkeys raised began to increase again and reached the high point in 1928, when nearly 60,000 birds were raised on the project.

The prices used for comparison with production are the average prices received on farms of the United States for the months of November, December and January of each year. The actual average prices received by local growers would have been preferable, but were not available for the earlier years. It is probable that the actual prices received followed the same general direction as the curve of average prices for the United States. It appears that the average United States farm price must exceed 30 cents in order to hold production of turkeys in the Newlands Project to a maximum.

Turkeys as well as dairy cows are found in greatest number on the smaller farms of the project. There were only 17 farms out of a total of 367 where the number of turkeys exceeded 400. Nearly one-fourth of the turkeys were grown in flocks containing between 100 and 200 birds, while 26 per cent were in flocks containing less than 100 turkeys. Nearly 79 per cent of the turkeys were grown on farms having less than 80 irrigated acres of land, indicating that the small farmers are producing the bulk of the turkey crop.

CHICKENS

The lowest number of chickens on farms of the Newlands Project was reported in 1918 when there were only 20,220 on hand. The highest number was reported nine years later in 1927 when the census showed 94,931 on hand. The average price for eggs was unusually low that year, which caused a reduction in the number of chickens in 1928 to 75,000. Since 1918 there has been a fairly consistent increase in the number of chickens in the project.

In Table XIII is shown the number of chickens on the Newlands Project and the average United States price on farms of chickens and eggs from 1914 to 1929, inclusive. These numbers and prices are also shown graphically in Chart 10.

The small farms containing less than five irrigated acres of land had the largest size flocks, the 15 flocks in this group averaging 382 hens per flock. On farms larger than this there was apparently no relationship between the size of farms and the average size of flocks. It appears from the census that there are 68 farms on the project without chickens. In the 421 flocks, the average number of laying hens per flock was 135.

The estimated sales of eggs in 1929 were 14,539 cases or 93 eggs per laying hen. Even when due allowance is made for the average number of eggs used per family, the average production per hen was less than nine dozen eggs. This is somewhat too low for profitable egg production.

TABLE XIII

Number of Chickens on Farms of the Newlands Project and U. S. Average Price on Farms from 1914 to 1929, Inclusive

Year	Number	U. S. Average Price — Chickens*	U. S. Average Price — Eggs†
1914	27,899	11.5	19.8
1915	22,912	12.0	19.0
1916	29,270	14.6	23.3
1917	24,056	18.4	33.0
1918	20,220	23.0	34.9
1919	25,932	24.2	41.8
1920	28,780	22.8	39.3
1921	28,582	19.3	25.3
1922	44,131	18.2	24.7
1923	45,240	18.3	25.2
1924	49,896	19.2	26.1
1925	54,833	20.7	28.3
1926	70,632	20.7	27.5
1927	94,931	19.8	24.2
1928	75,000	22.1	27.4
1929	81,384	21.0	32.1

*Prices of chickens are averages from July of year given to following July.
†Egg prices are averages from April of year given to following April.

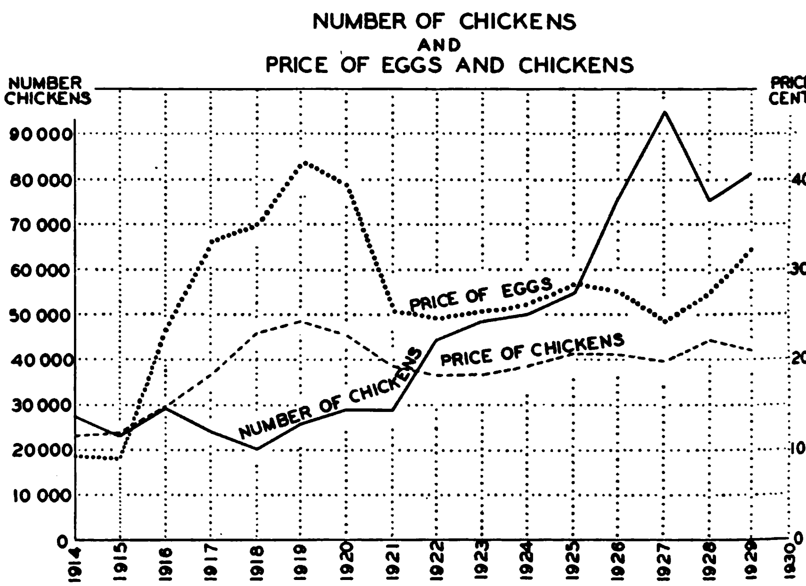


Chart 10. Graph showing number of chickens on the Newlands Project and the average U. S. farm price of chickens and eggs.

RABBITS

The production of rabbits within the project has recently increased to a point where the industry is of economic importance. In 1929 a total of 17,604 rabbits was reported on 113 of the 601 farms. Flocks smaller than 25 rabbits were most numerous, but 58% of the total number are in five flocks, containing more than 500 head in each. One-fourth of the rabbits are on farms having less than five acres of irrigated land. Farms larger than 120 acres have few rabbits.

HORSES AND MULES

The number of horses and mules on farms of the project reached its maximum in 1921, when 4,038 were reported, but since that time there has been a general downward trend in numbers. During the war period new land was steadily being brought into cultivation as a result of the stimulation of high prices paid for all farm produce. This preparation of new land required more than the usual amount of horse power. Since 1920 there has been no general development of new land and less power has been necessary to farm the lands already in cultivation.

As a result, the number of acres farmed per horse has increased rather slowly up to 1924, but more rapidly since that date. Probably very little of this reduction in the number of horses required is due to the increased use of tractors in the Newlands Project, although the replacement of horses by tractors is one of the main causes of the reduction in the number of horses in some other parts of the United States.

TABLE XIV

Horses and Mules on Newlands Project and Number of Irrigated Acres per Animal

Year	Horses and mules Number	Cultivated area Acres	Cultivated acres per work animal
1914	3,483	27,261	7.8
1915	3,780	27,058	7.2
1916	3,911	27,086	6.9
1917	3,467	29,421	8.5
1918	3,734	33,234	8.9
1919	3,582	35,219	10.0
1920	3,875	36,722	9.5
1921	4,038	36,753	9.1
1922	3,730	36,151	9.7
1923	3,822	35,781	9.4
1924	3,818	37,933	9.9
1925	3,397	37,936	11.2
1926	3,314	39,598	11.9
1927	3,374	40,826	12.1
1928	3,164	40,603	12.8
1929	2,757	39,581	14.3

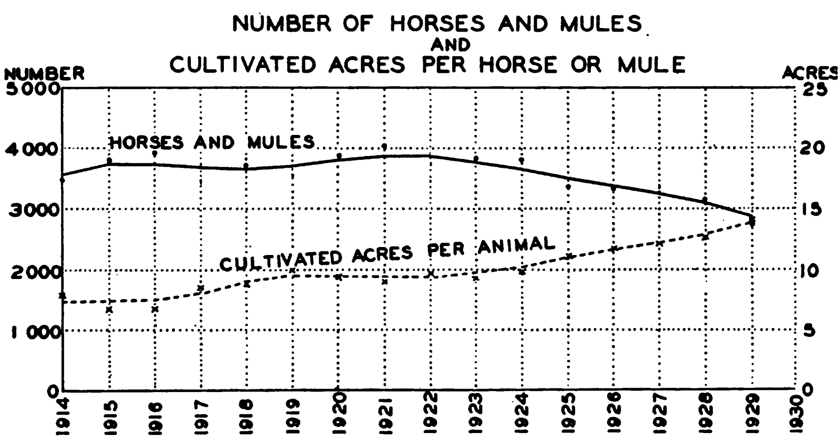


Chart 11. Average number of horses and mules on the Newlands Project and the number of acres of cultivated crops per animal.

BEES

Reported stands of bees have never exceeded 3,000 in the history of the census. The lowest number reported was 1,267 in 1922, and the highest number was 2,983 stands in 1921. In 1916, 1921 and 1925 the number of stands exceeded 2,900. Honey sales reported in 1929 were 135,385 pounds. The number of stands of bees reported each year from 1914 to 1929 are given in Table XV.

TABLE XV

Number of Stands of Bees on the Newlands Project, 1914-1929

Year	Number	Year	Number
1914	1,621	1922	1,267
1915	2,500	1923	2,302
1916	2,958	1924	2,249
1917	1,933	1925	2,913
1918	1,589	1926	2,607
1919	2,821	1927	2,722
1920	2,683	1928	2,898
1921	2,983	1929	2,148

MISCELLANEOUS LIVE STOCK

While of negligible economic importance now, it is of statistical interest to note that the 1929 census included one registered stallion, 34 goats, 18 skunks and 10 foxes.

NUMBER OF FARM UNITS ON NEWLANDS PROJECT

In 1929 the number of farms reported in the census was 691, but this figure included about 90 units which were operated by farmers living on other farm units. If the definition of a farm used by the United States Census Bureau is adopted, then there were about 601 farms on the project in 1929. The same holds true for previous years, so that the number of farm units reported is somewhat greater than the actual number of farmers and farm operators. The farm units shown by the annual census schedules may be used to show trends in the number of units farmed. A reduction in the number of units reported does not necessarily mean that some farms have been abandoned, but may indicate the consolidation of certain farms with others.

If the number of farms operated by single individuals or firms had been counted, this trend toward consolidation could have been much more accurately determined. In almost every part of the United States there has been a trend towards larger farms by the consolidation of two or more farms, and it would be of interest if this tendency could have been charted for the Newlands Project.

In Table XVI is shown the number of farm units reported by the census from 1912 to 1929, with schedules of the whites and Indians reported separately when the figures were available. The actual number of farm families or operators will be somewhat less than the figures given, since more than one farm unit is operated by some of the farmers. The maximum number of farm units was reported in 1921, 1922, and 1923. The results are shown graphically in Chart 12.

TABLE XVI

Total Number Farm Units, 1912-1929

Year	Total number	Number operated by Indians	Number operated by whites
1912*	497		
1913*	494		
1914*	504		
1915	571	65	506
1916	584	64	520
1917	600	52	548
1918	648	53	595
1919	694	62	632
1920	742	51	691
1921	788	63	725
1922	778	59	719
1923	788	64	724
1924	762	?	?
1925	761	56	705
1926	737	56	681
1927	?	?	?
1928	681	1	680
1929	694	1	693

*1912, 1913 and 1914—If counted, the Reservation was on one schedule only.

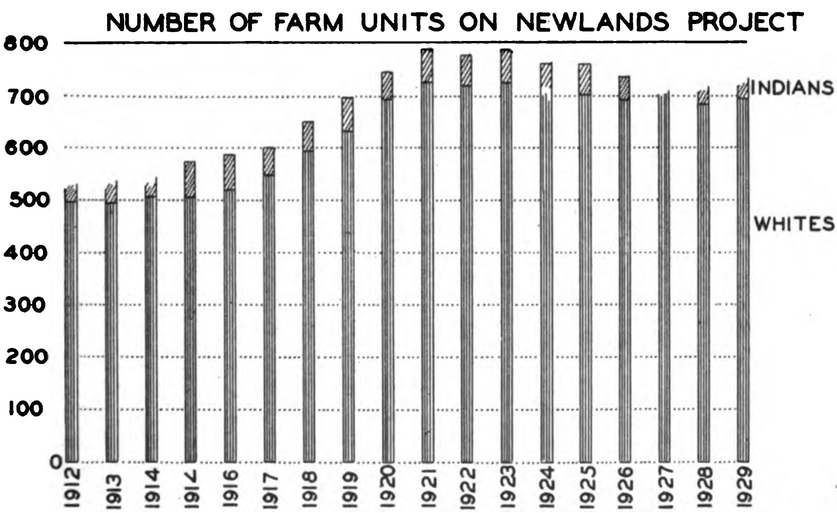


Chart 12. Graph showing the number of farm units on the Newlands Project, 1912-1929. One farmer may operate more than one farm unit so that the actual number of farms is slightly less than shown in the chart. The number of Indian units was not given for the years 1912, 1913, 1914, 1924, 1927, 1928 and 1929.

TABLE XVII

Distribution of Size of Farm Units in 1929. Community Pasture, U. S. Experiment Farm, and Indian Units Are Not Included

Size of Farm Unit: Range in irrigated acres	Size of Farm Unit: Average size Acres	Number of farm units	Total number of irrigated acres
1– 5	1.5	32	48
5– 10	8	31	251
10– 20	16	72	1,132
20– 30	26	92	2,404
30– 40	36	109	3,903
40– 60	51	152	7,729
60– 80	74	93	6,882
80–120	97	49	4,751
120–160	149	32	4,363
160–320	249	17	4,247
320 up	915	12	10,972
		691	46,682

In Table XVII is shown the distribution of the farm units according to size. Ninety of these units were farmed as part of the other 601 units, so that there is a slight shift toward the larger farm units.

The units containing less than 10 irrigated acres contain many divisions of land made subsequent to the original settlement. Most of these smaller units are situated near town and are operated by part-time workers or by rabbit and poultry men, who concentrate their efforts on a small area and buy most of their feeds.

Records are not available to show the changes that have taken place in the operating size of farms since the project was first settled, but the fact that the number of farm families has decreased since 1923 indicates that a consolidation of some farms has taken place which would result in an increase in the operating size.

POPULATION

The farm population of whites and Indians is given in Table XVIII and Chart 13. The white population showed an increase until 1922, since then there has been a decline in farm population, such as has taken place generally throughout the United States during the same period. In 1929 there was an average of four persons per white farm family on the project, when the permanent hired help are included as part of the farm family.

TABLE XVIII

Total Population Separated into Indians and Whites, 1913-1929

Year	Total population	Indians	Whites
1913	1,635		
1914	1,867	200	1,667
1915	1,986	165	1,821
1916	2,022	135	1,887
1917	2,197	149	2,048
1918	2,268	172	2,096
1919	2,386	203	2,183
1920	2,523	172	2,351
1921	2,652	268	2,384
1922	2,754	185	2,569
1923	2,737	239	2,498
1924	2,668	374	2,294
1925	2,549	264	2,285
1926	2,616	260	2,356
1927	2,537	?	?
1928	2,471	250	2,221
1929	2,554	145	2,409

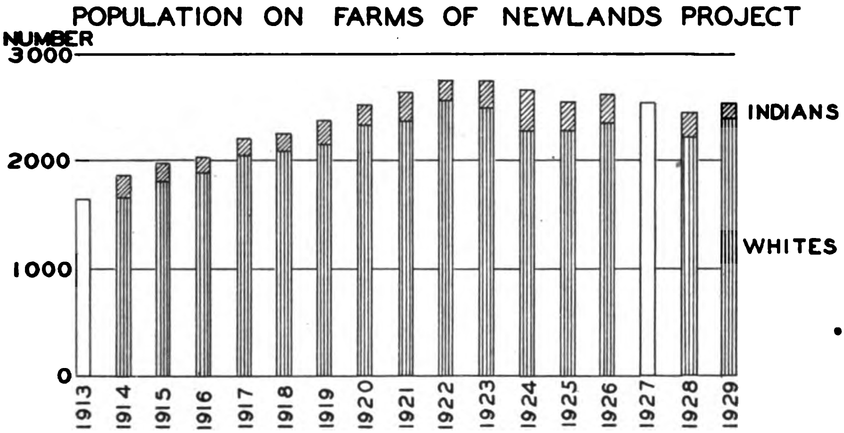


Chart 13. Graph showing population on farms of the Newlands Project 1913 to 1929. White and Indian population were not segregated in 1913 and 1927.

TENANCY

A rapid rise in tenancy has taken place since 1910 as indicated by records of the United States census and the project records. The following percentages for 1910 and 1920 are taken from the United States census reports for Churchill County for those years and the other percentages are from the project schedules:

Year	*Tenancy*
1910	6.8%
1920	7.8%
1924	12.1%
1928	22.3%
1929	31.1%

Very little increase in land tenancy occurred up to 1920, but since that date the change has been going on at a rapid rate. Six per cent increase occurred between 1928 and 1929.

Of the 601 families resident on the project in 1929, 137 or 23% were tenants. It is interesting to note that this 23% of the farm families operated 14,502 acres or over 30% of the irrigated acreage, indicating that the larger farms are passing into tenant's hands more rapidly than are the smaller ones.

TABLE XIX

Acreages of Principal Cultivated Crops Newlands Project, 1912-1929

Year	Alfalfa, old	Alfalfa, new	Wheat harvested	Barley	Canta-loupes	Corn*	Pota-toes	Oats	Other grain	Onions	Miscel-laneous	Total
1912	12,912	3,319	2,484	2,259	......	......	483	399	....	....	1,012	22,868
1913	13,960	4,523	1,590	1,880	......	......	416	283	....	38	5,194	27,884
1914	18,212	3,344	1,446	1,329	......	......	283	417	....	20	2,210	27,261
1915	18,273	2,070	2,582	1,733	......	97	196	428	....	17	1,662	27,058
1916	19,541	1,904	2,861	1,658	......	95	177	107	....	10	733	27,086
1917	20,360	2,141	2,532	1,116	......	86	322	27	....	14	2,823	29,421
1918	21,542	3,725	5,024	1,374	......	80	334	44	....	8	1,103	33,234
1919	24,188	3,854	5,423	519	......	204	152	31	....	1	847	35,219
1920	26,540	4,254	3,586	769	......	64	354	68	....	6	1,081	36,722
1921	28,287	2,923	2,443	732	129	63	484	60	....	2	1,630	36,753
1922	29,943	1,163	2,410	437	336	160	870	72	....	6	754	36,151
1923	28,210	1,907	3,116	451	350	367	659	70	....	6	645	35,781
1924	30,652	1,166	4,081	297	532	259	273	62	....	2	609	37,933
1925	28,183	2,459	4,670	760	510	392	152	55	....	9	746	37,936
1926	28,961	2,196	5,836	920	335	328	249	28	....	15	730	39,598
1927	29,849	1,977	4,829	1,209	261	424	542	......	99	19	1,617	40,826
1928	29,054	3,012	5,715	1,615	221	272	111	......	87	38	478	40,603
1929	28,922	3,169	5,285	1,081	318	215	101	......	78	9	403	39,581

*Included sorghum and millet until 1922.

TABLE XX

Numbers of Live Stock Newlands Project, 1914-1929

Year	Horses and mules	Dairy cows	All other cattle	Sheep	All hogs	Brood sows only	Tur-keys	All other poultry	Laying hens only	Rab-bits	Bees, stands
1914	3,483	1,503	4,540	1,981	3,515	......	6,972	27,399	....	....	1,621
1915	3,780	2,483	5,957	4,710	4,386	......	12,000	22,912	....	....	2,500
1916	3,911	2,587	7,802	5,452	6,092	......	15,239	29,270	....	....	2,958
1917	3,467	2,044	7,581	3,346	3,170	......	9,042	24,056	....	....	1,933
1918	3,734	1,895	8,839	3,560	3,343	......	4,746	20,220	....	....	1,589
1919	3,532	1,850	6,778	3,347	3,048	......	3,442	25,932	....	....	2,821
1920	3,875	2,072	7,428	4,611	2,211	......	3,624	28,780	....	....	2,683
1921	4,038	3,597	6,732	7,707	1,793	......	4,834	28,582	....	....	2,983
1922	3,730	3,457	6,232	7,961	3,214	......	12,100	44,131	....	....	1,267
1923	3,822	4,221	6,783	7,286	2,975	......	27,254	45,240	....	....	2,302
1924	3,818	4,712	7,850	4,624	2,296	......	22,415	49,896	....	....	2,249
1925	3,397	4,932	7,915	12,807	1,972	......	20,429	54,833	....	....	2,913
1926	3,314	5,341	9,618	7,930	2,265	......	30,618	70,632	....	....	2,607
1927	3,374	5,486	6,673	7,230	3,446	......	47,898	94,931	....	6,188	2,722
1928	3,164	4,890	6,809	9,481	2,598	399	57,594	75,000	....	6,791	2,898
1929	2,757	4,911	6,581	12,100	2,500	307	46,840	81,384	56,678	17,604	2,148

TABLE XXI
Number of Live Stock on Farm Units of the Several Size Groups, Newlands Project, 1929

Size of farm unit Irrigated acres	Cows	Turkeys	Hogs	Laying hens	Sheep	Rabbits
0– 5	23	717	3	5,725	5	6,280
5– 10	48	943	31	3,084	1	193
10– 20	198	3,418	60	2,717	157	1,585
20– 30	475	4,650	190	10,662	187	683
30– 40	705	7,130	187	4,767	741	1,365
40– 60	1,110	10,359	420	9,457	1,223	3,634
60– 80	881	7,837	358	10,015	1,264	422
80–120	621	6,002	294	4,592	2,239	3,250
120–160	368	2,543	129	1,474	180	0
160–320	223	499	207	3,249	1,690	97
320– up	185	366	583	971	4,399	0
Total*	4,837	44,464	2,462	56,713	12,086	17,509

*Totals do not include Community Pasture, Indian Reservation or Experiment Farm.

TABLE XXII
Per Cent of Live Stock on Farms of the Different Size Groups, Newlands Project, 1929

Size of farm unit Irrigated acres	Dairy cows	Turkeys	Hogs	•Laying hens	Sheep	Rabbits
0– 5	0.5	1.6	0.1	10.0	0.1	35.9
5– 10	1.0	2.1	1.2	5.5	0.0	1.1
10– 20	4.1	7.7	2.4	4.8	1.3	9.1
20– 30	9.8	10.4	7.7	18.7	1.5	3.9
30– 40	14.6	16.0	7.6	8.4	6.1	7.8
40– 60	23.0	23.3	17.1	16.6	10.1	20.7
60– 80	18.2	17.7	14.5	17.6	10.4	2.4
80–120	12.9	13.5	12.0	8.1	18.5	18.6
120–160	7.5	5.7	5.2	2.6	1.5	0.0
160–320	4.6	1.2	8.4	5.7	14.0	0.5
320– up	3.8	0.8	23.8	2.0	36.5	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

SUMMARY AND CONCLUSIONS

The records which have been presented show the development of the various farm enterprises of the Newlands Project from 1912 to the end of 1929. They show how the prices received for the various farm products affect the quantity produced and the type of farming that is carried on. It is apparent that the type of farming, the area planted to the different kinds of crops, and the number of each kind of live stock are not permanently fixed. In fact all these enterprises are so markedly influenced by prices received that there is from year to year a constant variation in production.

The effect of prices on the quantity of any commodity produced is not always apparent from the tables and charts for the reason that the prices of one commodity may influence the production of others. For instance, the number of dairy cows on the project bears a close inverse relationship to the price of alfalfa hay. A high price for alfalfa hay is associated with a reduction in the number of dairy cows, while a low price for alfalfa hay leads to an increase in the number of cows or other live stock.

These adjustments made by farmers because of price fluctuations frequently result in smaller profits than if no attempt at adaptation

had been made. A most outstanding example of this is shown by the fluctuations in the potato acreage illustrated in Chart 4, where it will be seen that, almost invariably, low prices were associated with large plantings and high prices with small plantings. The livestock charts show similar maladjustments, but with live stock, except poultry, the effect of price is somewhat more difficult to observe than it is with annual crops, for the reason that there is always a greater lag between the price of live stock or of livestock products and the resulting effect on the number of head than there is with annual crops. A farmer cannot quickly react to increased prices of dairy products or of beef cattle, and several years may elapse before high prices can have a marked effect on the quantity produced. On the other hand, a sudden drop in prices may result in an immediate reduction in numbers. In the case of most live stock, farmers can quickly adjust themselves to price reductions, but they need several years to build their herds up in response to price increase.

Economic changes have a more marked effect upon the size of flocks of chickens and turkeys than they do upon the size of herds of the slow breeding animals. In a relatively short time the size of flocks may show the effect of price changes. On the chicken and turkey charts one can find a number of interesting examples of adaptation of numbers of birds to the average prices of the previous year.

These adaptations in the number of acres grown, or in the size of herds or flocks, are invariably made as the result of prices in the past rather than from the viewpoint of the prices that may be received in the future.

There is every reason now why the more intelligent producers of farm crops should get this newer viewpoint and change the size of their various enterprises—not in accordance with prices that have been, but in accordance with prospects of future markets. The outlook reports now published at frequent intervals by the Bureau of Agricultural Economics make this possible, and those who use these forecasts should be able to adjust their enterprises somewhat in accordance with the prices that are to come.

Still too much of this opportunistic grasping for immediate gains is not beneficial either to the individual farmers or to the project. Jumping in and out of live stock to catch peak prices is a costly game. Farmers do not always take into consideration the high overhead cost burden that results from changes in their system of farming.

One cause of price extremes will be minimized when farmers as a group lay their plans on the basis of a long time outlook for their products, and do not completely abandon enterprises during low points of the price cycle. For the dairyman, a high hay price and a low butterfat price offer a profitable time to cull the herd, for at such times the excess feed can be sold at a good profit. Culling so improves the foundation qualities of the herd that when it is again built up it will be more efficient than before. Disposal of the entire dairy herd because of a year or two of unfavorable prices usually proves to be unwise when judged from the experience of the past or the outlook for the future.

During the past decade there has been little change in the size of the Newlands Project. Practically no development of new lands has taken place, but there has been a trend toward greater intensification. The

number of chickens, turkeys and dairy cows has so greatly increased that the total value of the agricultural commodities produced is greater than it was ten years ago. In this connection it is well to remember that during this period agricultural development has been at a standstill in the United States as a whole, and that many irrigation projects are in financial distress. That the Newlands Irrigation Project has been able to show some progress during this long period of agricultural depression indicates that it is economically on a sound basis.

In line with changes taking place in all parts of the United States, it is interesting to note that on the Newlands Project there has been a tendency towards a consolidation of farms and an increase of tenancy. The trend of farm population has been slightly downward since 1923 without any decrease in the cultivated area, which also is in line with trends over the country as a whole.

THE UNIVERSITY OF NEVADA
AGRICULTURAL EXPERIMENT STATION

Bulletin No. 121 RENO, NEVADA April, 1931

THE FITWEED (*Capnoides caseana*)

A Poisonous Range Plant of the Northern Sierra Nevada Mountains

By

C. E. FLEMING
Of the Department of Range Management

Assisted by

M. R. MILLER
Of the Department of Chemistry

and

DR. L. R. VAWTER
Of the Department of Veterinary Science

PUBLISHED BY THE UNIVERSITY OF NEVADA
RENO, NEVADA

CARSON CITY, NEVADA
STATE PRINTING OFFICE - - JOE FARNSWORTH, SUPERINTENDENT
1931

1[57]

The Station

NEVADA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

OFFICERS

STAFF

SUMMARY OF AVERAGE COSTS FOR 1928, 1929 AND 1930

PAGE

Automobile Account 14

The cost of running automobiles was $1.07 for every gallon of gasoline consumed.

Board and Lodging Account 17

Board and lodging cost was $1.33 per day. Board and lodging supplies consumed cost $0.81 per day.

Pasture and Grazing Account 19, 20

Pasture and grazing cost of all livestock was $1.36 per head, including young stock. A heavy investment per cow unit in grazing land, and expensive or extensive grazing leases, cause high pasture and grazing costs.

Horse Account 22–25

The cost of feed consumed by horses was $7.26 per head, or $0.32 per horse day worked. Horse cost was $0.43 per work day. On an average, each horse is used approximately 40 full days during the year.

Handling Cattle Account 27, 28

The cost of handling cattle was $2.55 per cow unit.

Feeding Cattle Account 30

The cost of feeding cattle was $1.97 per cow unit.

Feeds for Cattle 32

Hay fed per cow unit	.94 tons	$5.71
Grain fed per cow unit	3.70 lbs.	.06
Cottoncake fed per cow unit	44.72 lbs.	1.03
Salt fed per cow unit	7.08 lbs.	.07
Pasture and grazing cost per cow unit		1.58
Total feed cost per cow unit		$8.45

General Ranch Account 36

The net general ranch cost was $2.29 per cow unit.

Cattle Carrying Cost 39

The net carrying cost per cow unit was $14.88. The cost of feeds and the amount of hand feed consumed largely determine whether the carrying cost is low or high.

Bull Cost 41

On an average 24 breeding cows were run per serviceable bull. Approximately 10 per cent of the bulls of serviceable age were 7 years old or over.

Bull cost per breeding cow was $1.79, or $2.80 per calf branded.

Death Loss 42

The death loss among all cattle was 3.10 per cent. Death loss among all bulls was 5.23 per cent and among bulls 7 years old and over it was 16.5 per cent.

Calf Crop Percentage 44

Calves were produced by 63.92 per cent of the breeding cows. This is figured on the occupancy head of cows and the number of calves branded.

Cattle Production Costs 48

6 months calf	$28.46 per head	$0.077 per lb.
Yearling	34.64 per head	.066 per lb.
18 months	40.82 per head	.0596 per lb.
Two-year-old	49.10 per head	.0528 per lb.
30 months	57.39 per head	.0552 per lb.
Three-year-old	65.82 per head	.0598 per lb.

In round numbers a rancher having a $17 cow maintenance cost and an 82 per cent calf crop produces six months old calves for $7 per head less than he would with the same cost and only a 62 per cent calf crop.

Calf crop has its greatest influence on the initial cost of the calf.

Carying cost is the important factor affecting the production cost of cattle older than yearlings. In other words, carrying cost is more important than calf crop on the majority of ranches producing range cattle in Nevada.

CATTLE PRODUCTION COSTS IN NEVADA

The cattle ranch is a factory for the production of beef. The equipment necessary to produce the finished article consists of land, permanent improvements, machinery and equipment, bulls, breeding cows, horses, and such other livestock as sheep, hogs, and poultry in numbers considered necessary for efficient operation. Calves, heifers, yearlings, and two-year-old steers carried on the ranch are the raw product in the process of production. Heifers become a part of the required equipment at two years of age, as they replace aged cows. To keep the factory in operation requires managerial services, labor, administration expense, and the consumption of a wide variety of expendable parts and supplies.

With the settlement of the country and the passing of year-long forage on the open range, cattlemen have been compelled to grow an ever-increasing percentage of their own forage, which is pastured and hand fed. The march of progress, competition, changing conditions, and economic factors have forced them to acquire, fence, improve and operate more land. Therefore a heavier investment per unit is required in land, machinery, equipment, and in a better grade of cattle. With this added investment comes an increased cost in taxes, depreciation, and other overhead charges.

To keep this factory in operation requires the use of more labor and expendable parts and supplies for the production of feed and pasture. Irrigation ditches and laterals must be kept up, pastures reserved and meadows rehabilitated; hay and grain must be grown and hand fed to livestock during the winter months. Classification of stock cattle for grazing and feeding, and topping pastures with the beef, must be practiced. Young well-bred bulls must be used in sufficient numbers to insure a satisfactory calf crop of good breeding. Animal diseases, noxious weeds, and predatory animals must be controlled with more vigilance as outbreaks occur.

Irrigation streams are being adjudicated and stock water rights protected. The public taste wants a better product — younger beef with a higher degree of finish. The aged "horsey" type of longhorn steer is being replaced by his younger brother, eighteen to twenty-four months old, round and full in meat and flesh when finished for the shambles.

Both the character of the public appetite for beef and the economic conditions surrounding the ranch have changed rapidly in the past twenty years. These changing factors in the development of the industry have added materially to the cost of operating ranches and producing cattle. There was a time when a rancher could do all his own work on a saddle horse while depending upon the natural range resources; but this is rapidly becoming a thing of the past. A ranch manager of today must be a good executive, a shrewd business man, and a hard worker if he is to cope with the present economic conditions.

The successful operation of the cattle ranch of today requires:

(1) A balanced unit—the right number of cattle for the size and the productivity of properly proportioned areas of ranch and range.

(2) Skilled management and efficient ranch practices.

PURPOSE OF THIS BULLETIN

The purpose of this bulletin is to set forth a general summary of the method used in obtaining ranch costs, to give the costs of the important ranch accounts, the cost of producing cattle, and to point out some of the main factors which cause variations in cost.

SIZE, LOCATION, AND TYPE OF RANCHES STUDIED

This study was carried on during the years 1928, 1929 and 1930. and covered twenty-four cattle ranches, 26,411 head of cattle, and 271.539 acres of owned land. From this group twenty representative ranches

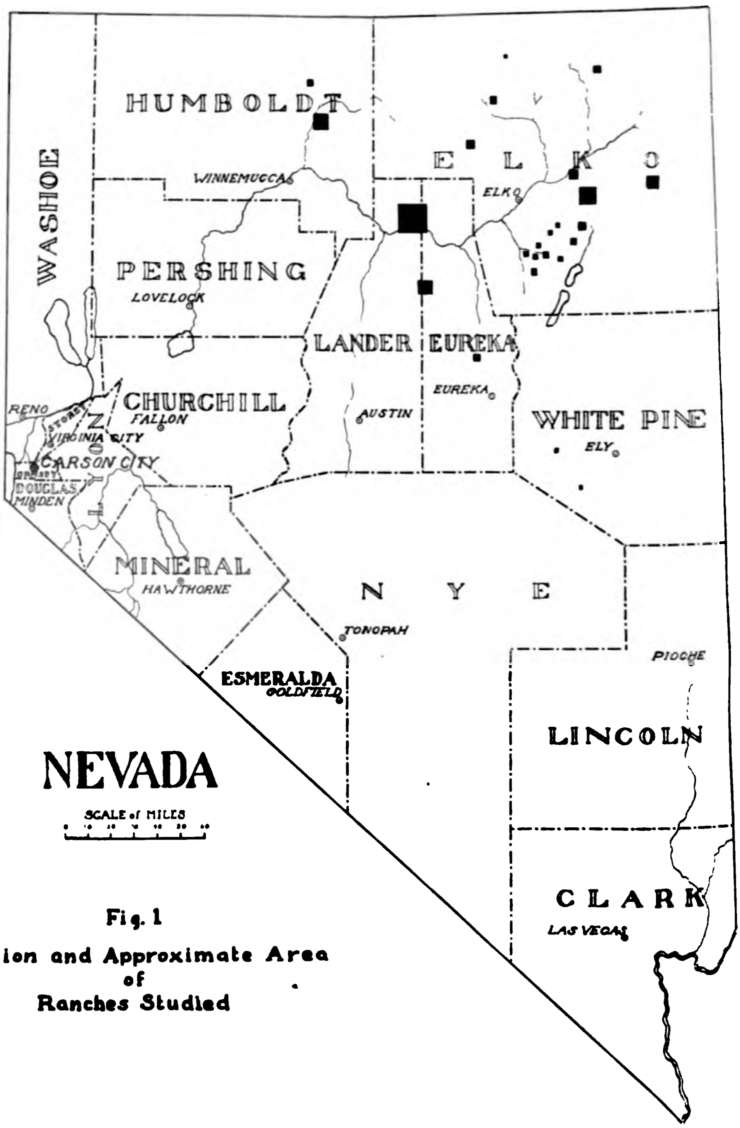


Fig. 1
Location and Approximate Area of Ranches Studied

were selected in order to present a fair average of costs. Ranches under study run from three hundred to four thousand head of cattle and are scattered in five large counties in eastern Nevada. They consist of ranches in the business of raising cattle, operating under the same general conditions, and were selected for the purpose of ascertaining the production costs involved on a straight cattle ranch. Modifications of operations are made in the different localities due to varying amounts of precipitation and length of grazing season.

The region studied produces 71 per cent of all the cattle produced in Nevada.

All of the ranches have winter quarters for feeding operations, and all of them produce hay. During spring, summer, and fall the cattle are grazed on open range; on the higher elevations during the summer months, and on the lower levels throughout the spring and fall. The altitude varies from 4,000 to 7,000 feet. Some ranchers do not run cattle on the Forest Reserve at all, and several have only small permits. The cattle are grazed on the open range for a period of three to nine months, depending upon location and available range feed. The remainder of the time the majority of cattle are run under fence on pasture or winter feeds.

The grazing areas, except for the higher summer ranges, are the Nevada sagebrush type. In this type of grazing, the following are the important grasses, weeds, grass-like plants, and browse in order of importance, according to their approximate feed value.

Grasses.

Blue bunch wheat grass.
Giant wild rye.
Slender wheat grass.
Field brome.
Wheatlike wild rye.
Idaho fescue.
Sixweeks fescue.
Fendler bluegrass.
Sandberg bluegrass.
Nevada bluegrass.
Big bluegrass.
Alpine timothy.

Grass-like Plants.

Hillside sedge.
Elk sedge.
Meadow sedge.

Weeds.

Mountain wyethia.
False yarrow.
Large bluebell.
Small bluebell.
Dandelion.
Balsam root.
Geranium.

Trees and Shrubs.

Mountain service berry.
Yellowbrush.
Mountain mahogany.
Mountain snowberry.
Lance-leaf yellowbrush.
Bitterbrush.
Red elder.
Willow.
Western chokecherry.
Fendler rose.

Harvest crop lands, ranch pasture, and grazing lands are necessary for cattle production in northeastern Nevada. The so-called wild hay meadows are composed mainly of timothy, red-top, wild and tame clover, and sedges, with a scattering of native grasses. Some alfalfa is

grown on a few ranches favorably situated. The irrigated pasture lands produce much the same grasses as the wild hay meadows. The plant composition of other pasture land is of the same type as the grazing areas in general.

METHOD AND PROCEDURE USED IN OBTAINING RANCH COSTS

There are so many different systems of bookkeeping and so many methods of interpreting cost figures after they are collected, that it was necessary to establish certain fundamental rules which must be adhered to throughout the investigation. The method to be adopted depends largely upon what the figures are intended to show. In this project the desire was to keep away from all hidden or paper profits, to put all ranches on an equal basis, and to find the direct as well as

Fig. 2. Typical Summer Range in the Ruby Mountains.

the indirect costs in the production of cattle. The following are a few of the more important principles adopted.

Interest.

The costs in this bulletin are exclusive of all interest charges. However, an inventory was kept of all livestock, land, machinery and equipment, so that valuations could be calculated to see what interest was earned on the investment, and for computing the earning power of land.

Prices Used.

Prices were established, exclusive of interest charges, on all livestock and food produced on the ranch for ranch consumption. These prices (Appendix 5–8) were kept at a constant figure in order to keep away from any paper profit due to fluctuations in value. As this bulletin deals only with the production cost of cattle, exclusive of interest, the prices thus established do not enter into the calculations except in

cases where such produce was directly consumed in the production of cattle—ranch produced beef used in board and lodging, ranch produced grain fed to livestock, etc.

Unpaid Labor.

Unpaid labor and unpaid managers are allowed a wage or salary in keeping with paid labor and paid managers, according to the work performed. (Appendix 1, 2).

Counts of Cattle—Occupancy Head.

Cattle were counted at the beginning and end of each year. However, due to purchases and sales during the year, neither of these counts will give the correct number of head on the ranch a full year. All classes of cattle were therefore placed on an occupancy basis, taking purchases and sales into consideration, in order to find the number of head of each class on the ranch a full year. The total occupancy head was the basis taken for figuring the percentage of death loss that had occurred during the year and the occupancy head of cows was used in figuring calf crop percentage.

Cow Unit.

A cow unit is a mature cow on the ranch a full year. The unit values used are:

1 mature cow	1 cow unit
1 branded calf or weaner	½ cow unit
1 yearling	¾ cow unit
1 two-year-old steer	1 cow unit
1 beef steer	1¼ cow units
1 bull	1½ cow units

Multiplying the occupancy head of each class of cattle by its unit value gives the number of cow units.

Purchased Cattle.

Cattle bought to build up the herd may cost more or less than production cost. If more the difference becomes a charge, if less a credit, to carrying cost. The difference between production cost and purchase price is handled in the same way as depreciation and spread over a period of years as a charge or credit covering the probable length of time the animal will be on the ranch. The cattle ranches presented make very few transactions of this character.

Charges and Credits.

Cattle and hay are the two big crops produced by Nevada cattle ranches. All other accounts are considered subsidiary to their production. Receipts, refunds, and inventory increases pertinent to such other accounts are credited to each respectively, giving the net cost. The hay is usually consumed by cattle at production cost, therefore the bulk of the receipts are derived from the cattle. However, revenue from both cattle and hay is credited to ranch profit or loss.

Raised Bulls.

A few ranchers operate a small registered herd and a good many run a few pure bred cows from which they produce a part of their stock bulls. At weaning time the production cost of these bulls is credited to carrying cost and charged to the bull account because some may

later be sold as herd bulls and such receipts are credited directly to bulls. If any bulls should die their loss would be charged to the bull account.

Distribution of Costs.

Cost items entering into ranch accounts are charged on the basis of use. Items such as labor, board and lodging, use of horses, haying extras, and feeds consumed, where the cost is exclusively for one operation, are kept separate and charged direct. Depreciation, use of automobiles, general supplies and repairs, where the use and cost pertain to several operations, are allocated to each as nearly as possible on the basis of percentage of use. This procedure is necessary because of the overlapping of some accounts. Its application may cause slight cost variations as between the segregated accounts; however, the carrying cost and cattle production cost would not be affected.

Averages.

Weighted averages are used in all average ranch computations; that is, total costs are divided by total units to find unit cost.

METHOD OF COLLECTING DATA

The Station entered into cooperative relationships with the cattlemen, through a term of years, in keeping actual records of all the factors entering into the cost of producing beef cattle for market. A field man visited the ranches on each route frequently, supervised the work, and assisted in keeping the books. These records were kept in a Time Book, Day Book, and Inventory. The data herewith presented are compilations and analyses made from these records.

DATA COLLECTED

Operation costs and physical data are entered under the following subdivisions:

Overhead Costs.

Insurance on buildings, machinery and equipment, charged directly to the item insured.

Taxes, both State and county, on ranch property, livestock tax and water tax, charged to the item taxed.

Depreciation on permanent improvements, machinery and equipment, computed by dividing the original cost of the item by its probable life, charged as nearly as possible to the account using such improvement or equipment.

Miscellaneous Management expense includes express, transportation, telephone, association dues, subscriptions to farm papers, and such other expenses as cannot be charged directly to any specific ranch operation. Such charges are therefore percentaged off to the various accounts.

Special Administrative Costs of considerable consequence, such as law suits, questions of title, etc., are not charged to any one year but are prorated over a number of years, depending on the nature of the

expense. This computation is made on the basis that the charge should be spread over its period of value to the ranch.

Labor.

Management Salary consists of paid and unpaid management salary. Unpaid ranch managers are allowed salaries comparable with paid managers holding similar positions (Appendix 2). All managers are allowed the regular going wage for ordinary labor. This amount is deducted from the manager's salary and charged to the work performed. The remainder of the manager's salary is prorated to the various ranch accounts according to the total days spent in each division.

Labor includes paid and unpaid labor chargeable to the several accounts on the basis of cost and days worked. Monthly time sheets are kept on labor, dividing the days worked into the proper accounts.

Labor Insurance consists of industrial insurance premiums paid on labor, and is charged to the various accounts according to the labor days.

Horse Labor. Horse days are kept track of and charged in the same manner as man labor days.

Parts and Supplies.

These include such items as fencing, board, haying extras, automobile parts, and gasoline, charged to their respective accounts. Other parts and supplies are allocated to the several accounts according to their percentage of use.

Feeds.

A record of the amount of each class of feed consumed by cattle, horses and other livestock is kept and such feeds are charged in at purchase price or production cost. (Appendix 5).

EXPLANATION OF MINOR ACCOUNTS

Charges from the above subdivisions made up the following minor accounts:

Automobile cost for all purposes is computed on the basis of total gallons of gasoline consumed. Records of the gallons of gasoline used in automobiles for ranch use and pleasure are kept. The percentage of use of automobiles for the different ranch purposes is then estimated and the cost prorated to the various accounts.

Board and Lodging cost per day is computed and charged to the respective accounts on the basis of days worked. Board for members of the family not working is not included in the production cost of cattle.

Pasture and Grazing charges are kept and allocated to cattle, horses, and other livestock on a head basis.

Horse Costs per day for all purposes are computed and charged to the different accounts on the basis of days worked.

Carry-Over Charges. Costs entering into the construction of permanent improvements and the production of feeds carried over do not

enter into the current year costs; accordingly such costs per cow unit and the total costs charged in various accounts to the current year are not one and the same thing. This principle applies to automobile, labor, board and lodging, horse costs, etc.

EXPLANATION OF MAJOR ACCOUNTS

The above Minor Accounts, together with all direct charges, make up the following Major Ranch Accounts, which in turn make up the two main cost divisions:

A. The Cost of Producing Hay.
   1. The cost of growing hay.
   2. The cost of haying.
      (A separate bulletin will be published on the cost of producing hay.)

B. Carrying Cost of Cattle.
   1. The cost of handling cattle.
   2. The cost of feeding cattle.
   3. The cost of feeds for cattle.
   4. The cost of general ranch operation.
   5. Cost of purchased breeding stock.
   6. Ranch produced bulls sold to bull account.

Bull Cost is found by multiplying the number of bull units by the carrying cost per unit, plus bull depreciation and death loss. This figure is divided by the number of breeding cows to give the bull cost per cow.

Cost of Production of Cattle. The carrying cost per cow unit, combined with bull cost per cow, death loss cost, and calf crop percentage, give the cost of production of the various ages of cattle.

MINOR ACCOUNTS

The Cost of Running Automobiles.

The automobile account includes the total cost of all automobiles for the year both for ranch purposes and pleasure. The cost for ranch purposes is charged to the various accounts on a percentage of use basis. The pleasure cost is charged to personal expense.

The automobile has replaced the horse for trucking and transportation to and from the ranch. Horses must still be carried to do most of the ranch work. The advent of the automobile has created a new ranch expense. Its use from a practical standpoint has to be justified by speeding up efficiency in saving time, hauling more tonnage, and the like.

AVERAGE COSTS PER GALLON

Overhead	$0.52
Parts and supplies (oil and repairs)	.27
Gasoline	.25
Management salary	.03
Total cost per gallon	$1.07

This average cost per gallon $1.07, divided by 12, the average miles per gallon, equals $0.089, the average cost per mile.

Chart Number 1

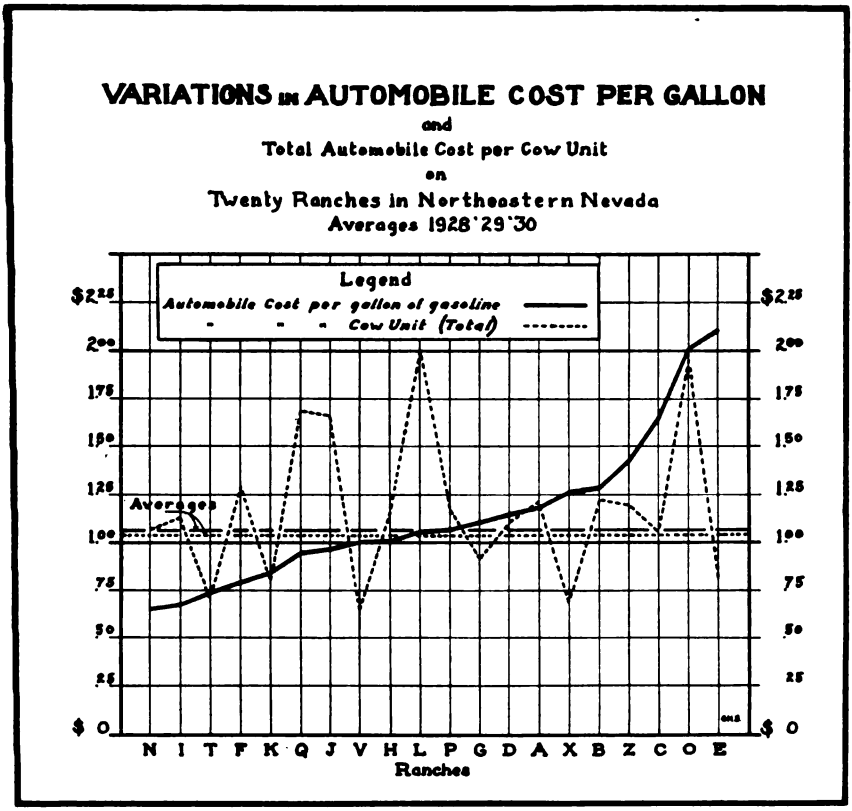


TABLE NO. 1
Variations in Automobile Costs

Ranch	Cost per gallon	Costs per Cow Unit: Total	Pleasure	Ranch use
N	$0.65	$1.07	$0.57	$0.50
I	.67	1.13	.17	.96
T	.74	.71	.02	.69
F	.79	1.30	.20	1.10
K	.84	.79	.12	.67
Q	.95	1.69	.12	1.57
J	.97	1.66	.30	1.36
V	1.00	.65	....	.65
H	1.00	1.16	.19	.97
L	1.06	2.00	.58	1.42
P	1.07	1.17	.33	.84
G	1.11	.92	.01	.91
D	1.15	1.11	.26	.85
A	1.19	1.22	.07	1.15
X	1.26	.68	....	.68
B	1.29	1.23	.15	1.08
Z	1.43	1.20	.05	1.15
C	1.65	1.06	.51	.55
O	2.01	1.96	.46	1.50
E	2.12	.81	.24	.57
Average	$1.07	$1.04	$0.16	$0.88

The foregoing table shows that the automobile cost per gallon varies from $0.65 to $2.12, with the average at $1.07.

There are too many variable factors which cause this difference to permit any definite conclusion regarding use of automobiles. A few of the variables are: Difference in size, number and type of automobiles, number of cow units, miles from railroad, kind and condition of roads, size and distribution of ranch and range, and the personal factor which governs the use of the car.

However, there are a few points well worth consideration. Cattle ranchers' investment in automobiles, when compared with their investment in other ranch machinery, often appears heavy and out of line. For instance, twenty-eight per cent of the total investment in ranch machinery and equipment is tied up in automobiles and trucks. When compared to other ranch machinery, automobiles and trucks are comparatively short-lived. At best, depreciation is a big factor. Careful consideration should be given to proposed use before purchasing. A touring car doing the work of a truck is expensive transportation. Big cars operated over rough mountain roads quite often could be replaced with lighter machines at a lower cost. In fact, the use of any car for a purpose to which it is not suited is costly. The automobile, unless judiciously used on cattle ranches, proves to be a burden.

Other things being equal, the majority of ranchers near trading centers have more auto travel than those farther away. Frequent trips to town are made for repairs and supplies in small lots. The ranchers farther away plan ahead, make occasional trips and lay in supplies in large amounts, thereby reducing automobile transportation.

Some part of the automobile cost finds its way into all ranch accounts, either directly or indirectly. It is first charged to the minor accounts, such as Board, Pasture, and Horses, and as these accounts are carried into the major accounts a part of the automobile cost goes with them. Then too, these major accounts, Feeding Cattle, Handling Cattle, Producing Hay, and General Ranch, all receive their share of the automobile cost as a direct charge.

It can be easily seen that the total automobile cost, like other total minor costs, becomes interwoven in carrying cost to such an extent that it is not practical to find the total amount of such minor costs which is included in carrying cost for the year. However, the ranch must pay for the automobile, whether it is charged to carry-over hay, to permanent improvements, or to hay directly consumed during the year. Therefore, the total cost of the automobile was divided by the total cow units, giving the cost per cow unit. This cost varies from $0.65 to $2, averaging $1.04 per cow unit. Of this total cost, $0.88 is charged to Ranch Operation and $0.16 to Personal.

The Cost of Board and Lodging.

The cost of board and lodging per day is based on all ranch labor days, together with family and personal board and lodging days. All cooks' wages are entered directly to board and lodging. Ranch produced food supplies are charged in to board at production cost (Appendix 8). Board and lodging costs are then charged to the various accounts on the basis of labor days worked.

Average Board and Lodging Cost Per Day

Overhead	$0.18
Labor	.33
Management salary	.02
Food supplies	.81
Gasoline for lights	.01
Automobile (.045 gals. per day x $1.07 per gal.)	.05
Gross cost per board day	$1.40
Credits: Receipts from meals, food supplies	.07
Net cost per board day	$1.33

The most important item entering into this account is the value of food supplies consumed during the year. To this cost cooks' wages, overhead, etc., are added, making up the total cost.

Chart Number 2

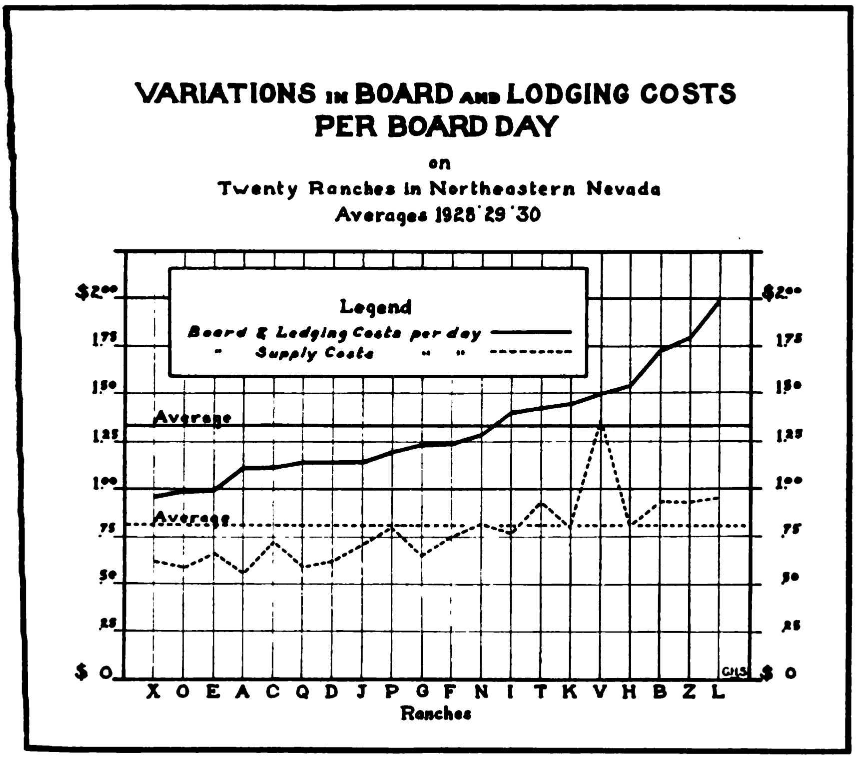


TABLE NO. 2

Variations in Board and Lodging Costs Per Day

Ranch	Food supplies	Total	Ranch	Food supplies	Total
X	$0.62	$0.96	F	$0.75	$1.24
O	.58	.98	N	.82	1.28
E	.66	.99	I	.77	1.41
A	.55	1.11	T	.93	1.43
C	.72	1.12	K	.80	1.45
Q	.58	1.14	V	1.37	1.50
D	.62	1.14	H	.81	1.54
J	.71	1.14	B	.94	1.73
P	.80	1.20	Z	.94	1.79
G	.65	1.23	L	.96	2.00

Board and lodging cost varies for $0.96 to $2 per day. The average cost of $1.33 per day, or $40 a month for each person, over and above wages, runs labor cost up to a figure that is not generally realized. With monthly wages approximating $50 and found, total labor cost averages $90 per month.

Board and lodging supply cost includes both purchased and produced items. The account consists of food supplies, such as groceries, dairy, poultry, and garden products, together with expendable supply items such as dishes, bedding, fuel, etc. Board and lodging supply cost varies from $0.55 to $1.37, with an average of $0.81 per day.

All ranches produced the bulk of the meats consumed. The great majority produced dairy and poultry products in quantities sufficient for home consumption. Out of this representative group of twenty ranches, seven maintained good home gardens, seven had gardens of little consequence, and six had none at all. In some instances location and conditions were not adaptable to gardens. One ranch produced no home grown food supplies whatever, with the exception of beef. Groceries, dairy, poultry and garden products were all purchased. This ranch made more than the customary replacement purchases of kitchen utensils and dishes. Including such purchases its board and lodging supply cost was $1.37 per day, which is $0.56 above the average. It is difficult to establish the amount of customary replacements of this nature; however, it is clearly evident that a good share of this cost is attributed to the fact that all food supplies, excepting beef, were purchased. Buying dairy and poultry products was especially costly.

Since each ranch carries the expense of board and lodging for family and personal days, as well as labor, cow unit costs are given to point out the significance of this account to the complete ranch operation under existing conditions. These are average figures for the twenty ranches:

	Board days per cow unit	Board cost per day	Board cost per cow unit
Labor board days	1.95	$1.33	$2.60
Family and personal days	.54	1.33	.72
Total board days	2.49	$1.33	$3.32

The $3.32 per cow unit is the total cost for all board and lodging, and is not shown again because part of it is in carry-overs and part in minor accounts, as explained under the Cost of Running Automobiles.

Investments in elaborate dwellings, mess and bunk houses, store rooms, etc., add to depreciation, upkeep, and repair costs, which are reflected directly in board and lodging. Simple, comfortable, and durable ranch houses are the most economical in the long run. In many cases all meals are prepared and served in the ranch house, eliminating the need of a mess house. On the majority of ranches the cattleman's wife does most of the cooking. This is particularly true on ranches running under 1,000 head of cattle. The housewife maintains a home, works with the chickens and garden, and in addition cooks for the hired help. In the successful operation of many outfits much credit is due to the housewife, whose prudent management, skillful hands, and capacity for work make the ranch a home as well as a place to live.

Volume production involves more labor, with more board days per cook, which lowers board cost per day. Small outfits which require a cook for very few men can hardly escape a comparatively high board and lodging cost per day.

Home grown garden produce in quantities sufficient for ranch use is desirable, probably more from the standpoint of variety, better living, and convenience, than cost. In most instances such produce amply provides the table with food which would be served sparingly if purchased. If conditions permit, all ranchers should produce most of their dairy, poultry, and garden products.

Meat plays a very important part in the ranch diet. Keeping meats during hot weather is quite a problem. Exchange of meat with neighbors, corning and curing are remedies practiced to check this leak. They are timely jobs and if neglected prove costly. The slaughtering of mature animals for ranch use is undoubtedly good economy where meat in such quantities can be taken care of and utilized.

Food waste due to poor cooks, neglect, and poor storage facilities causes board costs to go up. A good cook has more responsibility in holding board costs in line than is generally realized.

Pasture and Grazing Account.

All livestock are grazed in common on the ranch. Horses, sheep, and

Fig. 3. Garden Produce for Ranch Use.

small livestock are grazed in numbers considered sufficient to run the ranch. Pasture and grazing costs are allocated to cattle, horses, and other livestock on the basis of use and number grazed. To establish a basic unit for this account, five head of sheep or other small livestock are considered equal to one horse or cow, irrespective of age.

This pasture cost does not take into account cut-over hay land that is grazed by stock. The reason for this is that all taxes on hay land were charged against hay and all fence repair against pasture, because it was assumed that the amount of each chargeable to the other would balance and thus save the complication of dividing them on a use basis.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Labor days per head	.0626	Average wage per day	$1.879
Board and lodging days per head	.0626	Average board cost per day	1.33
Gallons of gas used in autos	.06	Auto cost per gallon	1.07
Horse days per head	.04	Horse cost per day	.43

AVERAGE PASTURE AND GRAZING COST PER HEAD

Overhead	$0.63
Labor—days x wage per day	.12
Management salary	.05
Labor insurance	....
Board—days x cost per day	.08
Parts and supplies	.05
Automobile—gals. x cost per gal	.06
Horses—days x cost per day	.02
Grazing leases and fees	.38
Gross cost per head	$1.39
Credits (sales of pasture)	.03
Net cost of pasture and grazing	$1.36

Under the heading of leases and fees have been included all charges for grazing that had to be obtained outside the ranch proper, *i. e.*, forest fees, short time leases, etc. These leases were generally for only a comparatively short period of time and did not include all the cattle on any ranch. However, these charges were allocated to the entire herd.

Chart Number 3

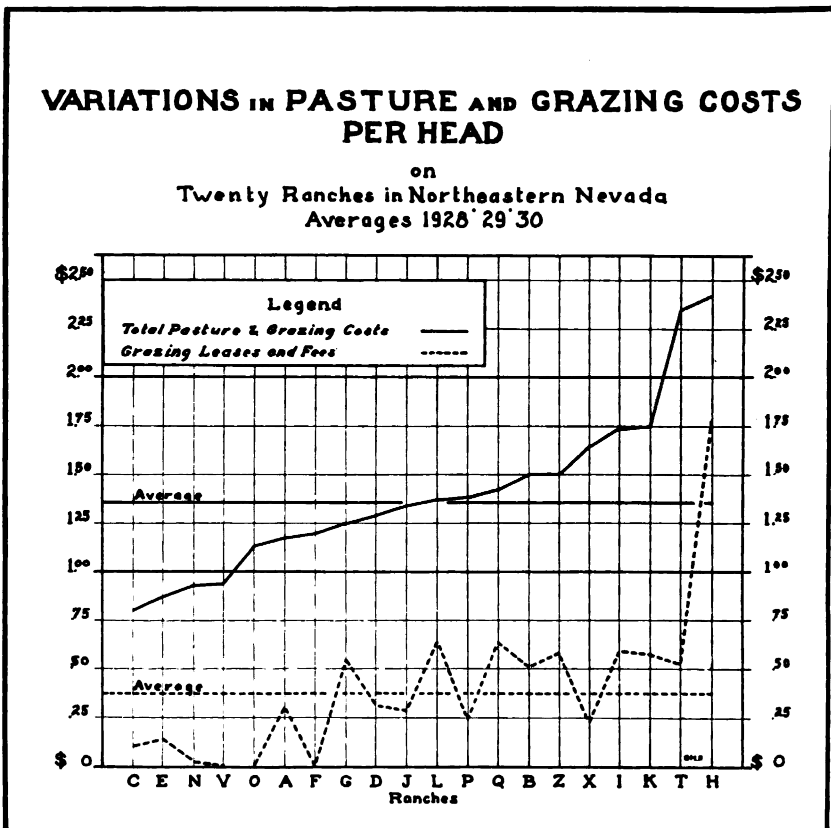


TABLE NO. 3

Variations in Pasture and Grazing Costs Per Head

Ranch	Leases and forest fees	Total	Ranch	Leases and forest fees	Total
C	$0.11	$0.80	L	$0.65	$1.37
E	.14	.87	P	.24	1.38
N	.02	.93	Q	.64	1.42
V	....	.94	B	.51	1.50
O	....	1.13	Z	.58	1.50
A	.31	1.17	X	.23	1.64
F	....	1.20	I	.60	1.74
G	.55	1.25	K	.58	1.75
D	.32	1.29	T	.53	2.35
J	.29	1.34	H	1.80	2.42

Pasture and grazing costs run from $0.80 to $2.42 per head, with an average of $1.36. The cost of grazing leases and fees has also been charted to show the direct relationship it has to the increase in pasture

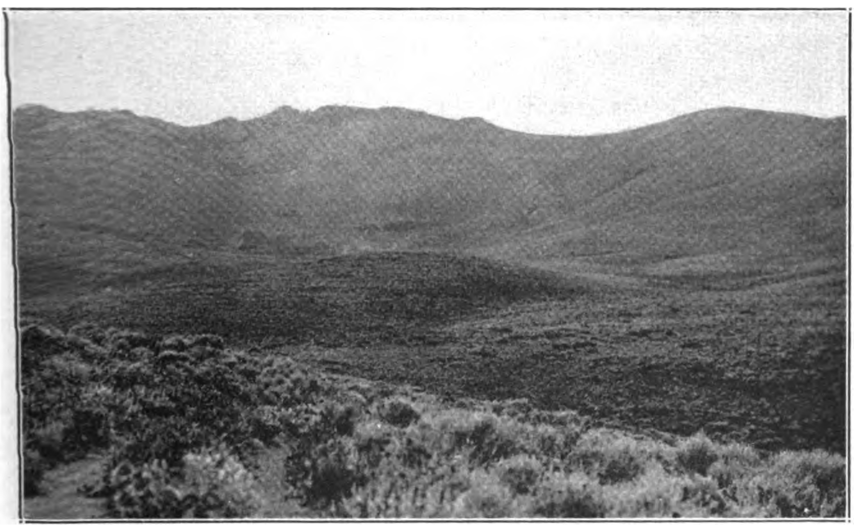


Fig. 4. Summer Range in Eastern Nevada.

and grazing costs. Ranches not favorably located with respect to the use of the public range are obliged to lease grazing lands or purchase pasture, oftentimes at costs which prohibit economic production. Grazing and pasture privileges, together with pasture costs on the ranch proper, constitute the total pasture and grazing account.

The cattle business does not warrant high pasture and grazing costs. Many of the cattle are grazed on the public domain. If pasture and grazing costs are high, then hand feeds and their cost should be correspondingly low in order to equalize the total feed cost. When both grazing and hand feeds are high it is difficult, if not impossible, to lower other ranch operation costs sufficiently to offset this handicap.

The amount of owned land per cow unit, carrying capacity, type of range, and length of grazing season bear heavily on pasture and grazing costs. Heavy investment in land causes increased overhead costs,

which are difficult to overcome. As a safeguard in the production of cattle, only enough land should be owned to provide fairly good control of feed and water. Buying more land, unless it materially speeds up production volume or efficiency, is apt to turn out an unsuccessful venture. Adding to capital investment unless new revenue is derived increases production costs and lowers profits.

Foresight is of prime importance in the grazing of cattle. Gains off grass are the cheapest; in fact, that is where the money in the range cattle business is made. The fields should first be topped with the beef turnoff, then followed with other classes of cattle which in turn are most in need of especially good feed. If possible, some good grass fields should be reserved for late fall and early spring grazing. Their use will reduce the amount of hay necessary to winter the cattle.

Outfits that can run their cattle on fairly good open range for five or six months out of the year have a decided advantage over those with

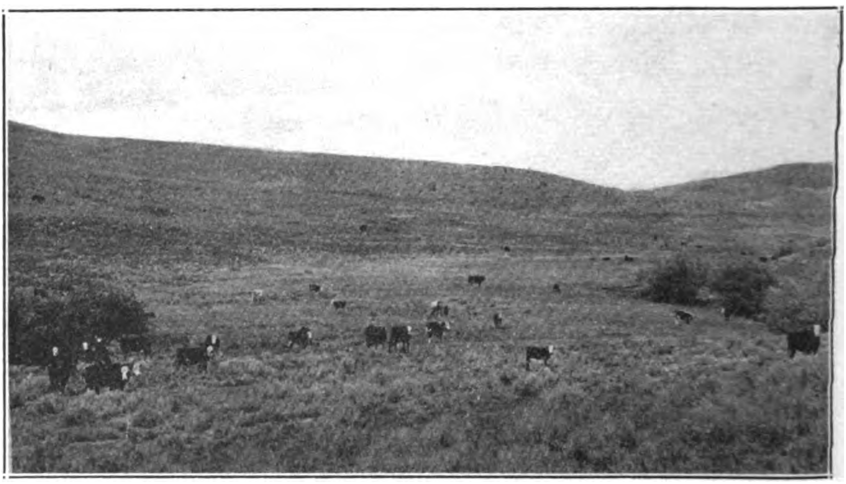


Fig. 5. Range Cattle on Mountain Meadows.

a short grazing season. While cattle are grazing on the open range, fields are rested, feed is conserved, and handling costs are usually reduced.

Classification of stock cattle should be practiced, giving the best location, with respect to feed, water, and shelter, to those classes most in need of special care.

HORSE ACCOUNT

Feed for Horses.

The cost of feed for horses consists of the amounts and costs of hay, grain, and salt consumed by horses, together with pasture and grazing costs per head.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Hay fed per head	.706 tons	Cost per ton of hay	$6.956
Grain fed per head	51.24 lbs.	Cost per lb. of grain	.0168
Salt fed per head	5.64 lbs.	Cost per lb. of salt	.0106

AVERAGE COST PER HEAD OF FEED FOR HORSES

Hay—tons fed x cost per ton		$4.91
Grain—lbs. fed x cost per lb.		.86
Salt—lbs. fed x cost per lb.		.06
Pasture and grazing	$1.38	
Forest fees	.05	
		1.43
Total cost per head of feed for horses		$7.26

Feed cost per head $7.26, divided by horse days worked per head 22.59, equals feed cost per horse day $0.32. Horse feed represents the largest single item entering into the horse account.

There is a great variation from the average in the amount of feeds given horses per head. For instance, the tons of hay vary from .30 tons to 2.16 tons; the pounds of grain from .00 to 200 pounds, and the salt from .06 to 12.80 pounds.

Chart Number 4

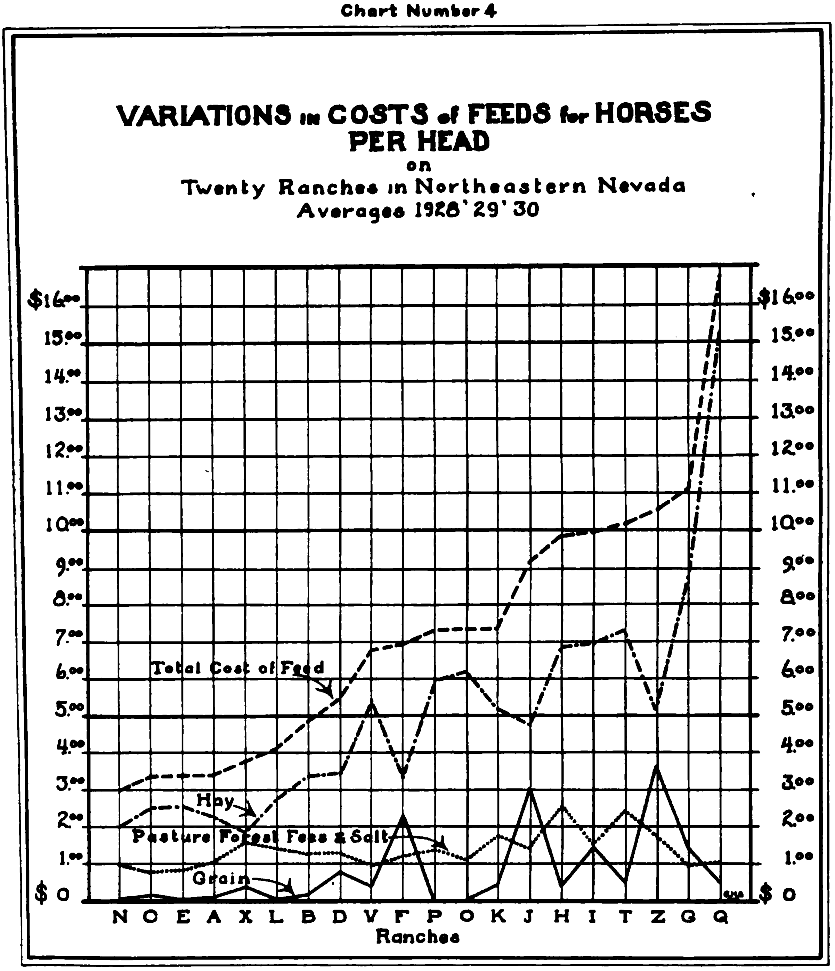


TABLE NO. 4

Variations in Feed Costs Per Head for Horses

Ranch	Hay	Grain	Salt pasture F. fees	Total	Ranch	Hay	Grain	Salt pasture F. fees	Total
N	$2.04	....	$0.93	$2.97	P	$5.91	....	$1.39	$7.30
C	2.48	$0.13	.75	3.36	O	6.20	....	1.13	7.33
E	2.55	....	.82	3.37	K	5.14	$0.42	1.77	7.33
A	2.26	.09	1.04	3.38	J	4.73	3.01	1.41	9.15
X	1.81	.35	1.55	3.71	H	6.83	.39	2.59	9.81
L	2.70	....	1.40	4.10	I	6.96	1.44	1.54	9.94
B	3.37	.16	1.29	4.82	T	7.26	.48	2.43	10.19
D	3.42	.75	1.30	5.47	Z	5.12	3.67	1.74	10.53
V	5.42	.38	.97	6.77	G	8.73	1.42	.95	11.10
F	3.37	2.29	1.24	6.90	Q	15.29	.50	1.01	16.80

Variations in grazing conditions surrounding the ranches cause wide differences in the amounts of hand feeds required. Total feed cost per

Fig. 6. Modern Corrals and Horse Pasture.

horse varied from $2.97 to $16.80. The average is $7.26. The accompanying chart on feed cost for horses illustrates the wide fluctuations on various ranches.

The cost per head of hay, grain, and pasture consumed varies in this account from production costs because a percentage of such feeds were purchased at figures below or above production cost. With few exceptions horses are grazed either on the open range or in pastures as much as possible. A few are ranged in the Forest Reserve, and this cost is allocated to all horses on a per head basis.

The difference in the amount of feed given horses is very noticeable. With seemingly equal conditions some ranchers feed horses from ten

to fifty per cent more hay and over twice as much grain as others in turning out practically the same amount of work during the year. This difference can generally be accounted for in the method of carrying the horses through the idle seasons, or it may be due to the time of year when run-out meadows or stubble fields are plowed up preparatory to spring seeding, in order to maintain hay and grain production. The preparation of land in summer or fall almost invariably reduces horse cost. In the fall after the haying season the horses are hardened and in good condition for heavy work. When the fall work is over the horses can be put out on pasture roughage, supplemented with straw and a minimum amount of hay for a short time during the severe winter weather. In the spring they will freshen up quickly on grass and be ready for the haying season. If the plowing and heavy crop work is left until spring the horses must be well fed throughout the winter to put them in good shape for hard spring work. In the spring the horses are soft; it usually requires more horses to do the work, more hay and grain are consumed, and the cost of feeding goes up.

Most ranchers feed and grow out their best colts very well, knowing that it takes feed to produce good work stock.

On comparing ranches, some carry mature work stock through the idle seasons on a maintenance ration of roughage and cheap feeds at a cost much lower than others. Horses are used in practically every ranch operation; hence, when the horse cost is high the cost of producing hay, handling cattle, feeding cattle, and general ranch costs all go up accordingly. Most ranchers, by planning their work, can carry mature horses through idle seasons at a comparatively low cost with no apparent ill effects.

Horse Cost.

The total horse costs are obtained by adding feed cost, overhead, and other pertinent items as listed below. In the main, horses are broken while at work. Accordingly labor cost for this purpose is charged to the various ranch accounts for which the work is done.

A horse day represents a full day's work for one horse, or its equivalent if horses are changed during the day.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Auto gals. per horse day	.022	Auto cost per gallon	$1.07
		Feed cost per horse day	.32

AVERAGE COSTS PER HORSE DAY

Overhead	$0.10
Management salary	.04
Parts and supplies	.03
Auto—gals. x cost per gal	.02
Feed	.32
Gross cost	$0.51
Credits (inventory increase, sales)	.08
Net cost per horse day	$0.43

Chart Number 5

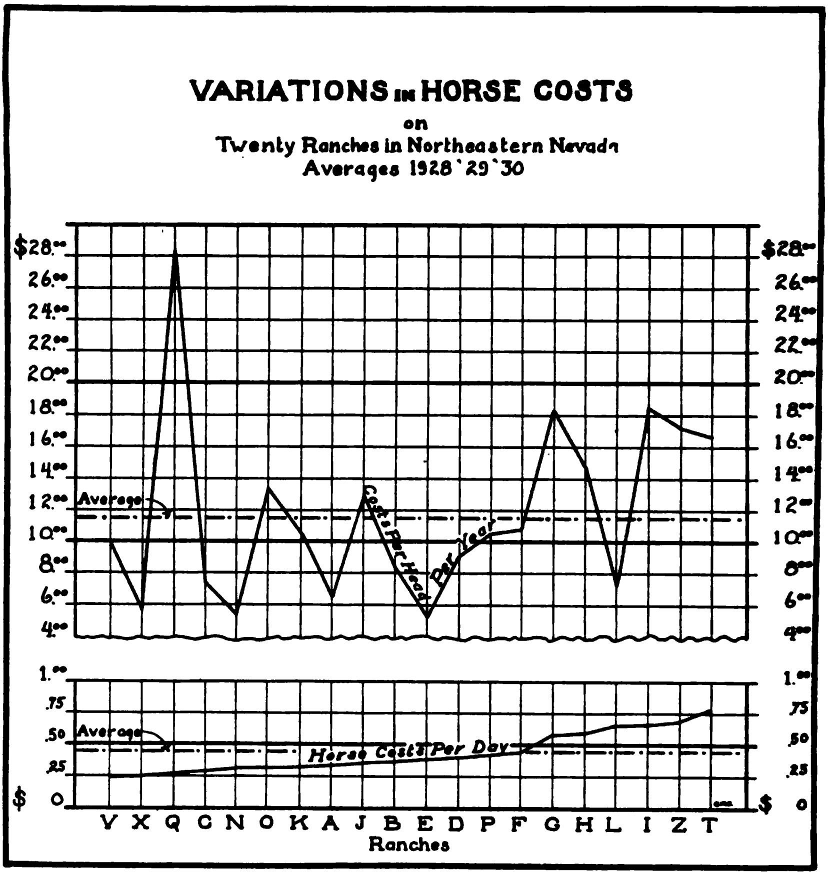


TABLE NO. 5

Variations in Horse Costs

Ranch	Cost per day	Cost per head	Ranch	Cost per day	Cost per head
V	$0.24	$9.25	E	$0.39	$5.29
X	.25	5.50	D	.40	9.12
Q	.27	28.64	P	.42	10.56
C	.28	7.36	F	.45	10.73
N	.31	5.19	G	.58	18.37
O	.32	13.32	H	.59	14.75
K	.33	10.55	L	.66	7.30
A	.34	6.55	I	.67	18.47
J	.36	12.97	Z	.69	17.36
B	.37	8.41	T	.78	16.72

The cost of a horse day varies from $0.24 to $0.78 per day, with an average of $0.43. This difference is caused by variations in methods of handling and feeding, and in the number of horses carried. The total number of horses carried consists of work stock, saddle stock, breeding stock, and colts coming on in numbers sufficient to fulfill replacement requirements, except in one or two cases. Considering all horses carried by the ranch, each horse would work only twenty-two days during the year. Each horse that is actually used sometime

during the year works approximately forty full days and is carried the rest of the year. Many teams are changed at noon and replacements are provided, all of which tends to decrease the days worked per horse. The very nature of the ranch operation makes it necessary to have available a considerable number of horses to take care of seasonal operations, such as haying and rodeo work. When these seasonal uses are past there is demand for only a few head of horses, the others remaining idle the rest of the year; this naturally increases horse cost.

Horse costs on these ranches run from $5.19 to $28.64 per head, averaging $11.60, a figure which warrants real consideration when planning the actual number of horses required to operate the ranch and fulfill replacement requirements.

The income from horses is exceedingly small. In recent years the only dependable outlet has been the sale of chicken feed horses at from $2.50 to $7 per head. Under present conditions it does not pay to carry more horses than are actually needed to operate the ranch. Additional horses take the place and consume the feed that would carry a

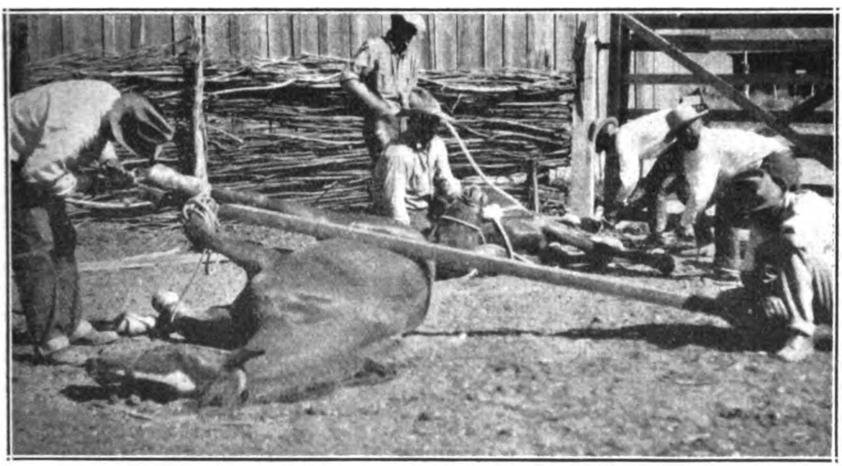


Fig. 7. Shoeing Colts for the Round-up.

few more good cattle. It is significant to note that one outfit runs 1,400 head of cattle, and produces an average of 1,200 tons of hay, with approximately the same number of horses as does another ranch running 300 head of cattle and producing 250 tons of hay. The income from sales of horses in both instances was negligible.

MAJOR ACCOUNTS

The following major accounts are given on a cow unit basis and go to make up the final carrying cost of cattle:

Handling Cattle Account.

This account consists of the costs of riding, branding, vaccinating, and dehorning.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Labor days per cow unit	.36	Labor cost per day	$2.21
Board days per cow unit	.36	Board cost per day	1.33
Auto gallons per cow unit	.114	Auto cost per gallon	1.07
Horse days per cow unit	.37	Horse cost per day	.43

AVERAGE COSTS PER COW UNIT

Overhead	$0.61
Labor—days x cost per day	.80
Management salary	.27
Labor insurance	.02
Board—days x cost per day	.48
Parts and supplies	.09
Auto—gallons x cost per gallon	.12
Horses—days x cost per day	.16
Total cost per cow unit	$2.55

Chart Number 6

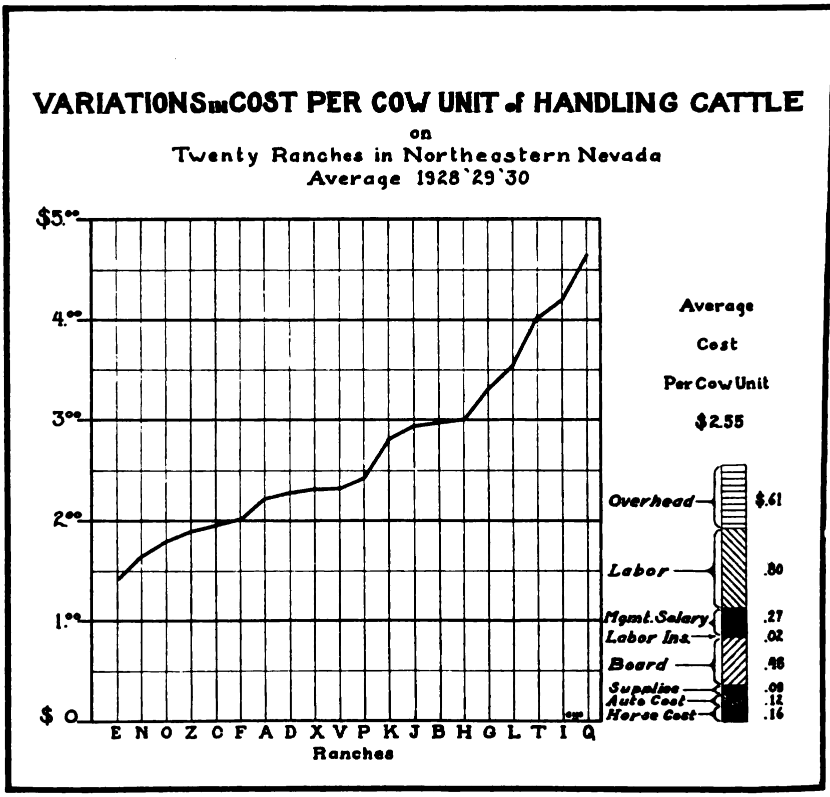


TABLE NO. 6
Variations in Handling Cattle Costs

Ranch	Cost per cow unit	Ranch	Cost per cow unit
E	$1.40	P	$2.41
N	1.66	K	2.83
O	1.80	J	2.95
Z	1.89	B	2.98
C	1.97	H	3.00
F	2.01	G	3.31
A	2.13	L	3.56
D	2.18	T	4.03
X	2.32	I	4.21
V	2.32	Q	4.63

Handling cattle cost varies from $1.40 to $4.63, with an average of $2.55 per cow unit. Man days and horse days spent handling cattle range from one-sixth to one day, averaging approximately one-third of a day per cow unit.

In a large measure differences are due to the set-up of various

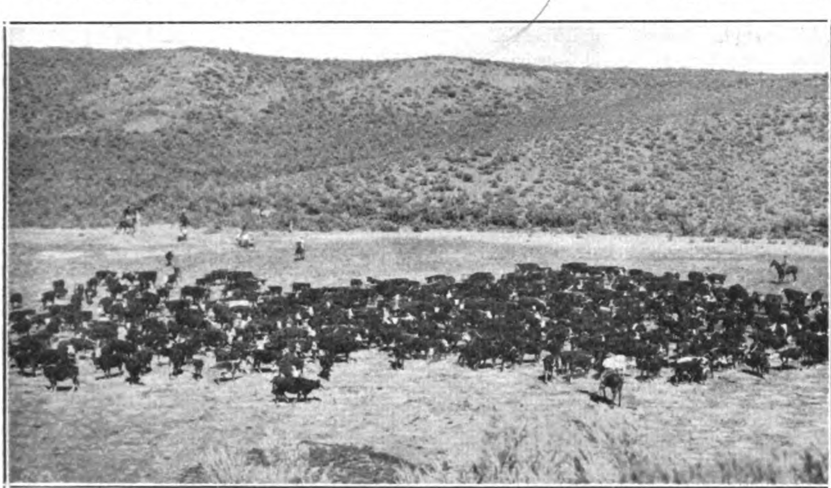


Fig. 8. A Round-up on the Range.

ranches. Location and distance from ranch to range also have a considerable bearing on this cost. Poor ranges necessitate more han-

Fig. 9. Branding Calves.

dling to effect equal distribution among classes of cattle that can best withstand the feed shortage encountered. Water troughs on the range facilitate better distribution of cattle. Small springs can be developed to provide more water than they will produce in their natural state.

More work of this kind should be done, especially on open grazing land. Quantity of water and distance between watering places have a direct bearing on beneficial use of feed and range conservation.

Long drives are hard on all classes of cattle, particularly on fat beef cattle going to market. From fifteen to twenty miles a day is sufficient for stock cattle, depending on the class and the total length of drive. Beef cattle should be handled with the utmost care and driven not to exceed twelve miles a day to insure delivery in good condition. Handling cattle is an art and becomes second nature to some men. A few disregard the natural habits and tendencies of the cow brute, suffering the consequences of poor condition, loss in weight, and lower price.

Elaborate corral equipment is not necessary, since cattle are only handled in the corrals for dehorning, weaning, and occasionally for branding. However, a few strongly built corrals conveniently arranged are a great asset to the ranch. Type of construction is usually governed by supply and cost of available material. Simplicity, strength, and arrangement should be given first consideration in planning construction.

Cattle costs on some ranches are increased purposely to effect better methods of handling while under fence during the fall and winter months. The cattle are classed up for pasture and winter feeding. Cows and calves, yearling steers, yearling heifers, calfy cows, weaners, and dry stuff are put in separate fields or feed lots. They are watched carefully, enough bulls are placed with the cows, and all weak stuff put by themselves and provided shelter and extra feed. Some increase in handling costs for these purposes appears entirely warranted and in the long run cuts down death loss and produces a higher return.

Feeding Cattle.

This account consists of the cost of hauling and scattering hay and concentrates to cattle during the winter months.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Labor days per cow unit	.35	Labor cost per day	$1.794
Board days per cow unit	.35	Board cost per day	1.33
Auto gallons per cow unit	.108	Auto cost per gallon	1.07
Horse days per cow unit	.494	Horse cost per day	.43

AVERAGE COSTS PER COW UNIT

Overhead	$0.18
Labor—days x cost per day	.62
Management salary	.26
Labor insurance	.02
Board—days x cost per day	.47
Parts and supplies	.09
Auto—gallons x cost per gallon	.12
Horses—days x cost per day	.21
Total cost per cow unit	$1.97

The cost of feeding cattle per cow unit varies from $1.14 to $3.74, averaging $1.97. Feeding cattle required from one-fifth to three-fifths labor days. The average is slightly over one-third of a labor day per cow unit. Labor days feeding were approximately double on ranches where less than 400 head of cattle were wintered, as compared with the larger herds where feeding operations were more concentrated.

Feeding days per cow unit were above the average on small ranches, and on large outfits with scattered properties. The number of horse days per cow unit feeding cattle presented a similar condition.

Chart Number 7

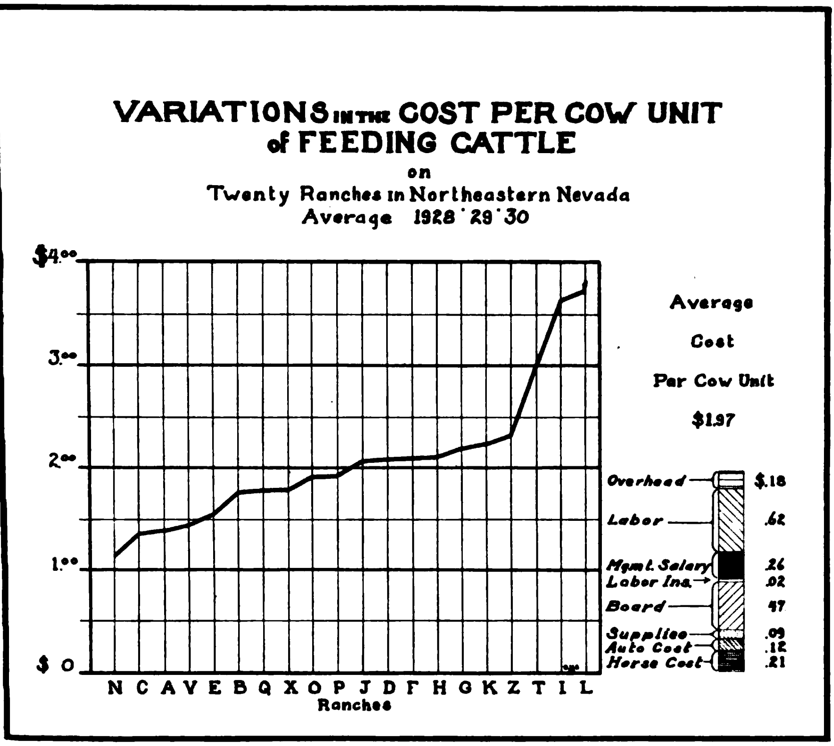


TABLE NO. 7

Variations in the Cost of Feeding Cattle

Ranch	Cost per cow unit	Ranch	Cost per cow unit
N	$1.14	J	$2.06
C	1.35	D	2.07
A	1.39	F	2.08
V	1.44	H	2.11
E	1.53	G	2.20
B	1.76	K	2.23
Q	1.79	Z	2.32
X	1.79	T	3.00
O	1.91	I	3.64
P	1.93	L	3.74

The relation of feed grounds to hay supply and the number of cattle fed per man are factors exerting the greatest influence on feeding costs. Under average conditions, with stack yards and feed grounds conveniently located, one man can feed and take care of around four hundred stock cattle during the hardest winter months, when hay comprises practically the entire ration. The figure varies in different localities due to the amount of pasture browse available. In light snow districts

under good conditions one feeder can care for a larger number. On the other hand, if the feed grounds are widely scattered and each man is not given enough cattle for a full day's work the cost goes up.

Ordinarily the larger cattle outfits which are able to place sizeable bunches of the several classes of cattle in separate feed lots reduce their feeding cost. Location, hay and water supply available, and class and number to be fed often make it impossible to provide each feeder a full day's work. Feed grounds conveniently located and providing plenty of good water and natural shelter are a great asset to a cattle ranch.

Feeds for Cattle.

This account consists of the amounts and costs of hay, grain, concen-

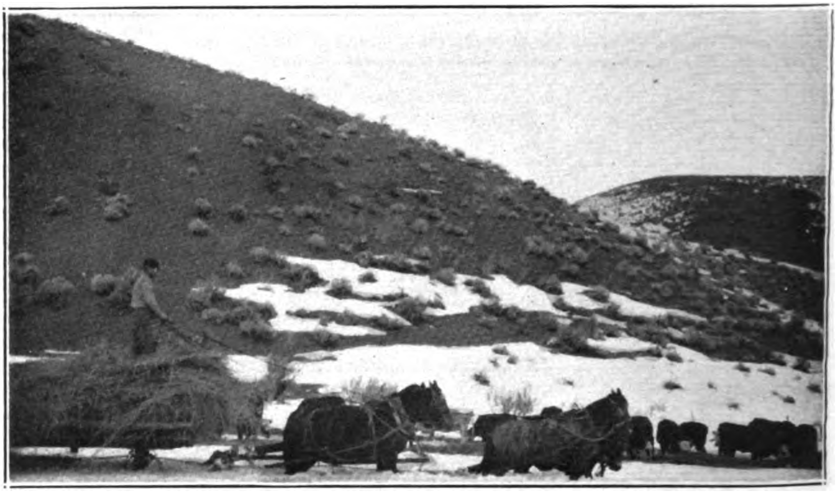


Fig. 10. Hauling Hay to Cattle.

trates, and salt consumed by cattle, together with pasture and grazing cost.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Hay fed per cow unit	.94 tons	Hay cost per ton	$6.075
Grain fed per cow unit	3.70 lbs.	Grain cost per lb	.015
Cottoncake and other concentrates fed per cow unit	44.72 lbs.	Cottoncake and other concentrate cost per lb	.023
Salt fed per cow unit	7.08 lbs.	Salt cost per lb	.01

AVERAGE COSTS PER COW UNIT OF FEEDS FOR CATTLE

Hay—tons fed x cost per ton	$5.71	
Grain—lbs. fed x cost per lb	.06	
Concentrates—lbs. fed x cost per lb	1.03	
Salt—lbs. fed x cost per lb	.07	
Cost of hand feeds consumed by cattle		$7.87
Pasture and grazing	$1.42	
Forest fees (allocated to all cattle)	.16	
Total pasture and grazing cost		1.58
Total cost of feeds for cattle		$8.45

On an average each mature cow consumed $8.45 worth of feed during the course of a year. Pasture costs are pretty well fixed, one year with another. Ranchers who own large tracts of pasture and grazing lands have high pasture costs. Those with sizeable areas leased likewise run high. Outfits owning a minimum amount of land with available public range have comparatively low grazing costs. Most of the concentrates fed cattle are purchased. In drouthy years large quantities are fed, the cost depending upon market price. The hay fed is largely ranch produced and comprises the bulk of the ration. Accordingly, the production cost of hay and the amount fed are two important items that must be given special consideration, if feed costs are to be held to a minimum consistent with economic cattle production.

Chart Number 8

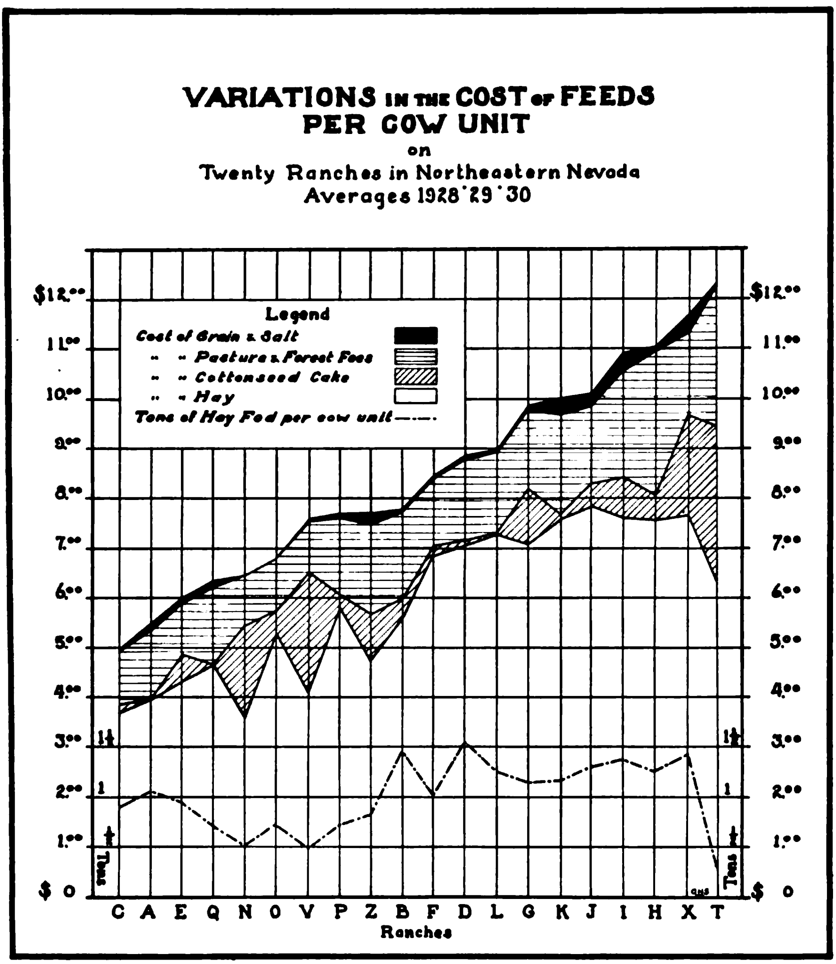


TABLE NO. 8

Variations Per Cow Unit in the Cost of Feeds for Cattle

Ranch	Hay	Cake	Pasture and F. fees	Salt and grain	Total	Ranch	Hay	Cake	Pasture and F. fees	Salt and grain	Total
C	$3.69	$0.15	$1.07	$0.06	$4.97	F	$6.83	$0.20	$1.37	$0.06	$8.46
A	3.93	....	1.38	.16	5.47	D	7.05	.10	1.59	.15	8.89
E	4.34	.51	1.05	.10	6.00	L	7.29	.03	1.58	.08	8.97
Q	4.65	....	1.52	.16	6.33	G	7.07	1.11	1.56	.11	9.85
N	3.54	1.88	1.01	....	6.43	K	7.59	.09	2.02	.31	10.01
O	5.25	.46	1.08	....	6.79	J	7.84	.45	1.57	.24	10.10
V	4.08	2.41	1.07	.03	7.59	I	7.61	.80	2.13	.36	10.90
P	5.80	.25	1.55	.09	7.68	H	7.57	.48	2.91	.08	11.04
Z	4.72	.92	1.83	.21	7.68	X	7.65	1.99	1.63	.36	11.64
B	5.57	.42	1.73	.06	7.78	T	6.36	3.11	2.79	.05	12.31

The costs at which hay and grain consumed by cattle are charged into this account vary somewhat from production cost because a percentage of such feeds was purchased at prices below or above production costs.

In Chart No. 8 the total feed cost per cow unit varies from $4.97 to $12.31, averaging $8.45. Since pasture costs are figured on the same basis for all ranches and the price paid for grain, salt, forest fees and cottonseed cake is approximately the same, the differences in these costs per cow unit are due to the amounts fed and not to variations in price. However, the cost of hay per cow unit depends upon differences in hay production costs as well as in amounts fed; therefore the tons of hay fed per cow unit have also been charted in order to give a more complete picture of the conditions. For instance, ranch V feeds half as much hay as A, yet the cost per cow unit is the same. Ranch T feeds only one-fourth of a ton per cow unit, yet the hay cost is high, due to a high hay production cost.

Because of the great difference in the amount of feeds per cow unit, the following table has been included.

Variations in Amounts of Feed for Cattle

	Low	Majority of Ranches From	Majority of Ranches To	High
Hay fed per cow unit, tons	.29	.72	1.30	1.56
Grain fed per cow unit, lbs.	....	......	8.69	15.99
Cake fed per cow unit, lbs.	....	3.25	63.74	134.12
Salt fed per cow unit, lbs.	.08	3.76	9.97	14.30

Feed consumed by cattle represents the largest single item which enters into carrying cost per cow unit. The amount fed depends upon the locality, length of grazing season, and weather conditions. A good many outfits bordering the desert feed from one-third to three-fourths of a ton of hay per cow unit. They are favorably located in this respect, being able to graze on the desert during the winter months, and on the higher elevations in the summer. Ranches in the higher elevations feed from three-fourths to one and one-half tons per cow unit, depending upon location and length of winter feeding season. Hay is supplemented with grain and cottoncake on many ranches, especially in short crop years. As a rule cattle are classified and concentrates are fed to weaners, calfy heifers or thin stuff.

To set a definite amount of feed necessary to carry a cow unit is not practical due to the many changing conditions. However, as a measure of safety ranchers on the higher elevations find it advisable to make provision for at least one ton of hay per cow unit, or its equivalent in hay and concentrates. Those in milder sections of the country are generally quite safe if they provide some concentrates and half a ton of hay per cow unit.

The amount of salt required is largely a matter of opinion among ranchers. In some sections of the country, particularly in desert or lake-bottom regions, even though cattle are given free access to salt at all times very little salt is consumed. Outfits on the higher elevations with pastures and hay fields well irrigated and well drained find that cattle have a craving for salt and consume it readily in much larger amounts than cattle on low lands.

Pasture and grazing costs are largely dependent upon availability of public range and the carrying capacity of the ranch proper. Grazing and hand feeding are so interrelated that it is difficult to draw conclusions separately. Ranches with low grazing and pasture capacities are compelled to do more hand feeding.

The location, the productivity of ranch and range, and the amount of owned land determine in a large measure the differences between feed costs per unit. As a general rule ranches with low year-round feed costs have comparatively low cattle production costs. Feed outlay is a heavy expense especially if much hand feeding is done. Many ranchers go on the principle that hay in the stack is the same as money

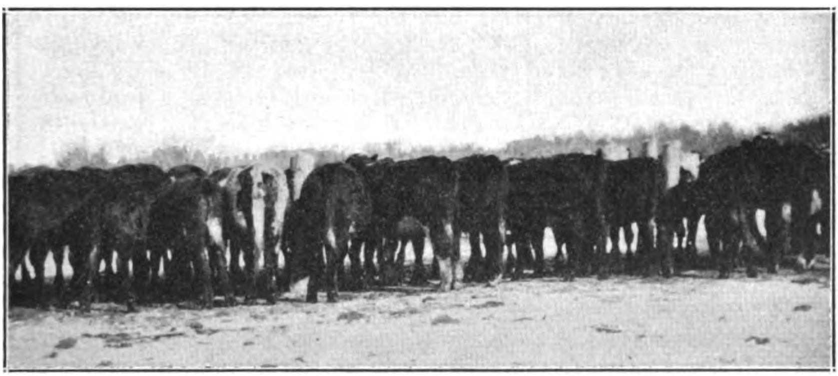


Fig. 11. Growing Out Weaner Steers.

in the bank. They guard it, feed cautiously, and take advantage of every opportunity to save hay. Their cattle go to the range in fair condition. In the long run those who practice this principle are best prepared for a long heavy winter, and apparently come out best in the end. Other outfits feed heavily and even buy hay to do it. Their cattle are in extra good condition when turned to the range. They usually carry more finish when marketed, but it is doubtful if the extra weight and slight price spread pay for the additional cost. In short crop years such an outfit cuts heavily into its herd at market time in order to balance up cattle with available hay supply. Prices under those conditions are low and receipts discouraging. The rancher with hay in reserve sells lightly under these conditions. When good years come and demand is keen he cuts and trims his herd, holding only his constant number of good age breeding cows and yearling and weaner steers.

The most general practice consists of feeding stock cattle heaviest the fore part of the winter. Cattle have a keen appetite for hay then, consume more, become strong and are prepared for severe weather.

During that period they are usually fed all they will clean up without waste. Later in the season the ration can be cut down considerably, depending on weather conditions. Some successful stockmen feed heavily for a month or so during heavy weather and then cut to a maintenance ration of hay and cured grass with good results.

Cows, calves, and young stock should be given the best hay on the ranch. If possible, alfalfa or clover hay should be worked into their ration. When these crops are not available on the ranch some operators supplement their grass hay with a one or two pound ration of protein concentrates for calves and weak stock.

Feeding a light ration of concentrates to young animals is quite general and worthy of consideration. It helps grow them out, slicks them up and they mature at an earlier age. Wintering cattle on concentrates along with ample rough forage is practiced on some ranches. This runs into money and should be well planned before being attempted by the average rancher.

General Ranch.

The general ranch account consists of all costs involved in producing small livestock (sheep, hogs, poultry, etc.), grain, and home grown food supplies.

Credits and charges for the enterprises involved are made covering sales at sale price, inventory changes, livestock feeds and produce consumed at production cost (Appendix 1–8). Grain fed cattle, food produce consumed in board, etc., are sold to those accounts at production cost and, since their production cost is already in the general ranch account, their receipts are credited to this account. When all pertinent charges and credits are accounted for, the remainder represents the net general ranch cost chargeable to the production of cattle.

PHYSICAL DATA

Variable Factors		*Unit Costs*	
Labor days per cow unit	.553	Labor cost per day	$1.926
Board days per cow unit	.553	Board cost per day	1.33
Auto gallons per cow unit	.122	Auto cost per gallon	1.07
Horse days per cow unit	.36	Horse cost per day	.43

AVERAGE COST OF GENERAL RANCH PER COW UNIT

Overhead	$0.30	
Labor—days x cost per day	1.06	
Management salary	.27	
Labor insurance	.02	
Board—days x cost per day	.74	
Parts and supplies	.15	
Automobile—gallons x cost per gallon	.13	
Horses—days x cost per day	.16	
Cost of produced food and grain on hand Jan. 1	.47	
Feed consumed by small livestock	.22	
Gross cost per cow unit		$3.52
Produced food consumed and on hand Dec. 31	$0.43	
Produced grain fed, sold, and on hand Dec. 31	.65	
Inventory increase in small livestock	.15	
Total credits per cow unit		1.23
Net cost of general ranch per cow unit		$2.29

Chart Number 9

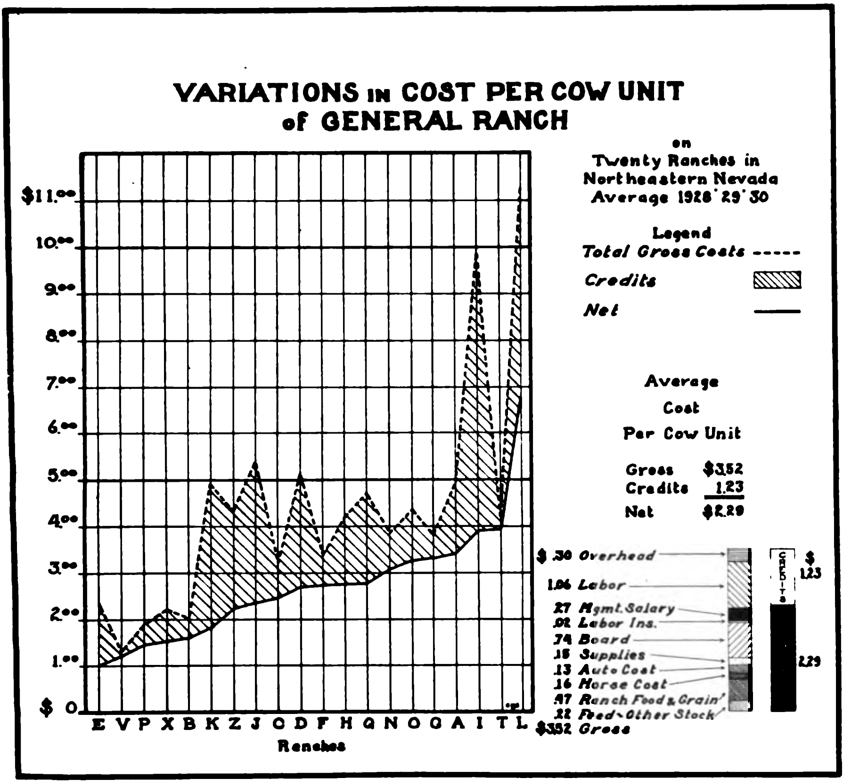


TABLE NO. 9

Variations in General Ranch Cost Per Cow Unit

Ranch	Gross cost	Credits	Net cost	Ranch	Gross cost	Credits	Net cost
E	$2.35	$1.32	$1.03	F	$3.37	$0.65	$2.72
V	1.25	.03	1.22	H	4.19	1.43	2.76
P	1.89	.44	1.45	Q	4.69	1.90	2.79
X	2.21	.69	1.52	N	3.86	.77	3.09
B	2.02	.44	1.58	O	4.35	1.07	3.28
K	4.93	3.13	1.80	G	3.80	.48	3.32
Z	4.35	2.12	2.23	A	4.93	1.51	3.42
J	5.38	3.02	2.36	I	9.88	5.98	3.90
C	3.20	.74	2.46	T	4.18	.21	3.97
D	5.11	2.41	2.70	L	11.27	4.53	6.74

The net general ranch cost per cow unit varies from $1.03 to $6.74, averaging $2.29.

Outfits of a diversified type which produce grain, small livestock, and ranch food supplies ordinarily have a comparatively high general ranch cost, with relatively high credits. As a rule, grain production is practiced by valley ranchers with inadequate cattle range. The grain is largely fed to livestock as a means of offsetting range deficiency. Grain production causes the greatest difference in gross general ranch costs. When good grain crops are produced the diversified type of ranch is able to hold general ranch costs pretty well in line with those of the straight grass ranch. During dry years such a rancher

is confronted with a higher cost, for in addition to purchasing feeds, his efforts and costs in producing grain are largely lost due to crop failure.

Not many range cattle ranches capable of grain production are

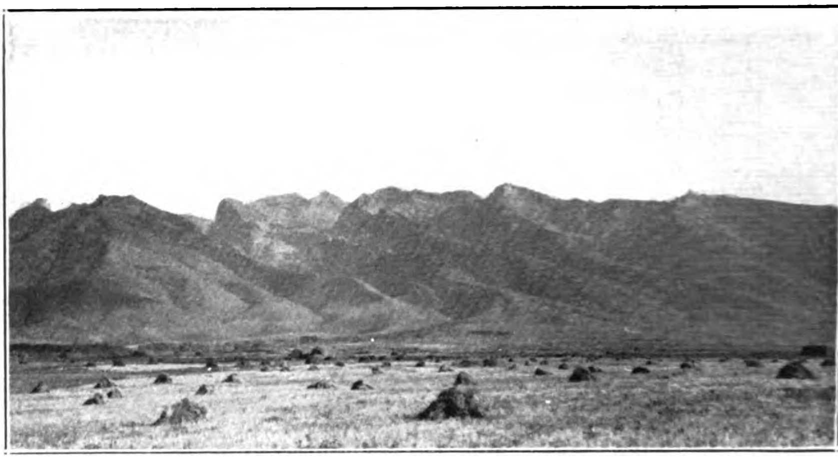


Fig. 12. Valley Ranch Suited to Grain Production.

located in a good grass country. Grain is planted only when conditions are extremely favorable. Usually a bumper crop is harvested and stored as a reserve feed for livestock. The supply may last for two or three years before being consumed.

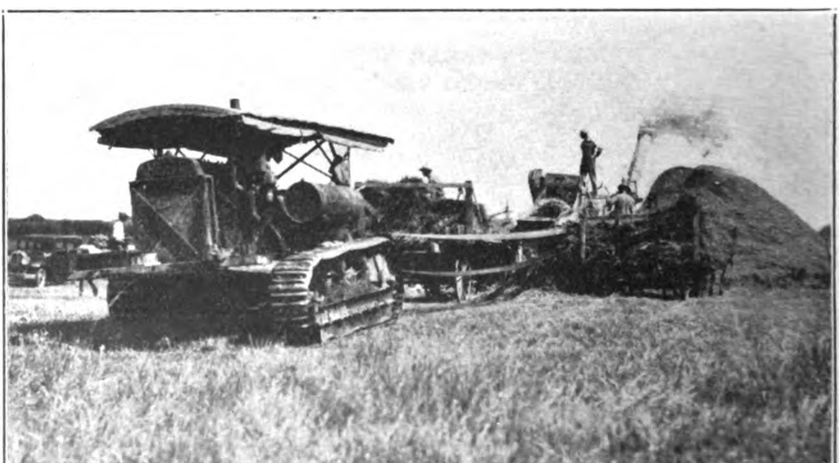


Fig. 13. Threshing Outfit in Operation.

The production of hogs, sheep, and poultry is undertaken mostly by the small operators. They do not have enough cattle to occupy their entire attention, the revenue from them usually is insufficient to carry

the ranch, and they work in sideline enterprises the better to balance their operation. On the smaller ranches this is entirely justified.

CATTLE CARRYING COST

This account is a recapitulation of all pertinent costs in connection with the operation of the ranch. The accounts which make up carrying cost have been presented and explained separately. The purchased breeding stock cost listed below represents the difference between purchase price and production cost of breeding cows and heifers, which is spread over their probable useful life. Credits listed below are general ranch credits, previously explained, and ranch produced bull calves sold to the bull account. Such bulls are credited to carrying cost since their cost is charged to the bull account. Net carrying cost per cow unit is the cost of supporting a cow unit on the ranch a full year.

Average Carrying Cost Per Cow Unit

Charges	Overhead	Labor	Management salary	Labor insurance	Board	Supplies	Feed for cattle	Automobiles	Horses	Prod. food and grain January 1	Feed for small livestock	Total
Handling cattle	$0.61	$0.80	$0.27	$0.02	$0.48	$0.09	....	$0.12	$0.16	....	....	$2.55
Feeding cattle	.18	.62	.26	.02	.47	.09	....	.12	.21	....	....	1.97
Feeds for cattle	....	....	....	....	....	....	$8.45	....	....	....	....	8.45
General ranch	.30	1.06	.27	.02	.74	.15	....	.13	.16	$0.47	$0.22	3.52
Purchased stock	.01	....	....	....	....	....	....	....	....	....	....	.01
Total charges	$1.10	$2.48	$0.80	$0.06	$1.69	$0.33	$8.45	$0.37	$0.53	$0.47	$0.22	$16.50
Credits—												
General ranch credits											$1.23	
Produced bulls to bull account											.39	
Total credits												1.62
Net carrying cost												$14.88

In reading these figures it must be remembered that these direct charges are not necessarily the total cost of the minor accounts. For example, the average auto cost per cow unit was given as $1.04 under the automobile account. Only $0.37 is shown here. The reason for this is that the automobile has also been charged into board, horses, cost of feed, etc., and makes up part of each of these accounts. Out of the $1.04, cost of the automobile per cow unit, $0.37 is shown as a direct charge, $0.16 was charged to pleasure, and approximately $0.16 was included in hay, under feed, leaving $0.35 scattered among the other minor accounts. This same principle applies to other figures given above.

Cattle carrying cost varies from $9.97 to $23.02 with an average of $14.88 per cow unit. Variations between carrying costs are due to the general set-up of the ranch which involves location, productivity, size, and balance, together with management practices and efficiency.

Carrying cost variations are charted herein, showing the cost range and the several accounts which make up this total cost. The same chart also shows the average of each account that goes to make up the carrying cost per head. These accounts are General Ranch, Feeds for Cattle, Feeding Cattle and Handling Cattle and they warrant strict attention

and careful supervision. The cost of feed consumed by cattle is the one big item to be watched. It is dependent upon the amount of hand feeds, pasture and grazing forage consumed by cattle and their costs, whether purchased or produced. It is practically impossible to offset excessive feed costs, even though rigid economy and efficient management are practiced in other ranch accounts.

A comparatively low carrying cost is a decided aid to success in the cattle business. To effect a low carrying cost necessitates close supervision of all contributing ranch accounts. A proposed change in practice which means additional cost should always be thoroughly investigated. Such a change should give real promise of added revenue over and above cost before being attempted. Depending upon the circumstances surrounding the set-up of every ranch there is a definite way of operation which will bring maximum returns. The problem resolves itself into management efficiency of individual ranches.

Chart Number 10

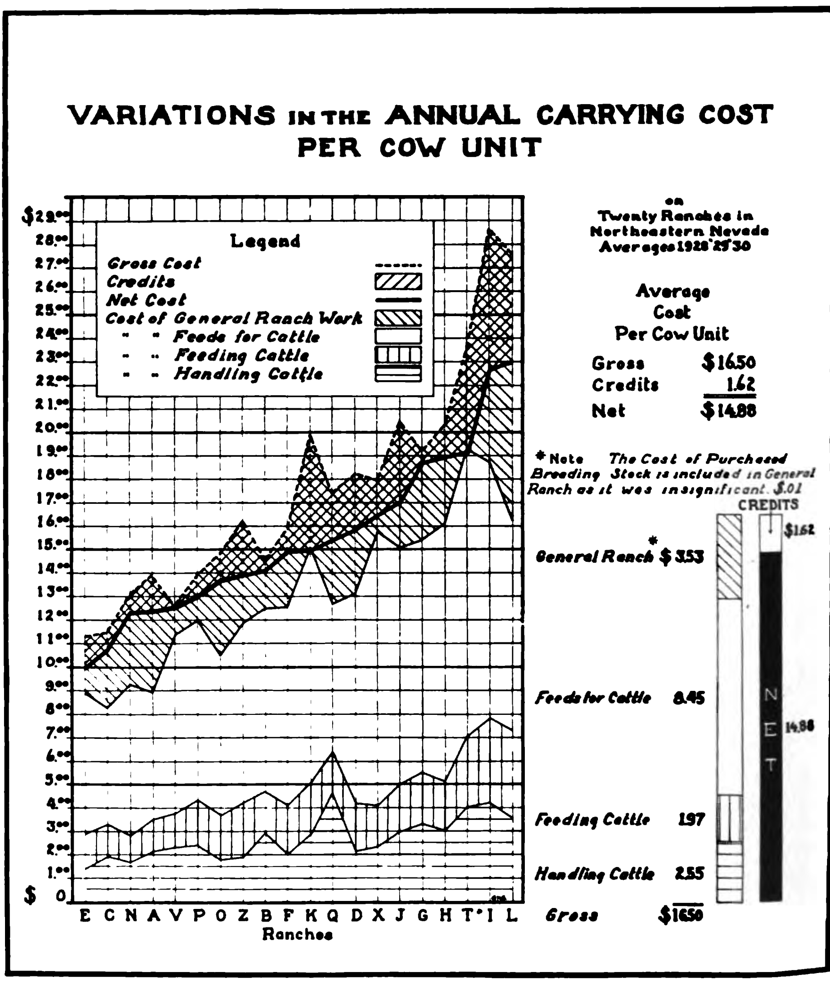


TABLE NO. 10

Variations in Carrying Costs Per Cow Unit

Ranch	Handling cattle	Feeding cattle	Feeds for cattle	General ranch	Gross cost	Total credits	Net cost
E	$1.40	$1.53	$6.00	$2.35	$11.28	$1.31	$9.97
C	1.97	1.35	4.97	3.20	11.49	.75	10.74
N	1.66	1.14	6.43	3.86	13.09	.76	12.33
A	2.14	1.39	5.47	4.93	13.93	1.51	12.42
V	2.33	1.44	7.59	1.25	12.61	.04	12.57
P	2.41	1.92	7.68	1.89	13.91	.84	13.07
O	1.80	1.91	6.79	4.35	14.85	1.07	13.78
Z	1.89	2.32	7.68	4.35	16.24	2.27	13.97
B	2.98	1.76	7.78	2.02	14.54	.44	14.10
F	2.01	2.08	8.46	3.37	15.92	1.01	14.91
K	2.84	2.23	10.01	4.93	20.01	4.99	15.02
Q	4.63	1.79	6.33	4.69	17.44	2.04	15.40
D	2.18	2.07	8.89	5.11	18.25	2.41	15.84
X	2.32	1.79	11.64	2.21	17.96	1.44	16.52
J	2.96	2.06	10.10	5.38	20.50	3.49	17.01
G	3.31	2.20	9.86	3.80	19.17	.48	18.69
H	3.00	2.12	11.04	4.19	20.35	1.43	18.92
T	4.03	3.00	12.30	4.18	23.51	4.36	19.15
I	4.21	3.63	10.91	9.88	28.63	5.98	22.65
L	3.57	3.74	8.97	11.27	27.55	4.53	23.02
Average	$2.55	$1.97	$8.45	$3.52	$16.50	$1.62	$14.88

BULL COSTS

A bull represents one and one-half cow units. Bull carrying cost is computed on that basis. Bull calves are appreciated in value until two years old on the basis of carrying cost and the period of time required to grow them out. Mature bulls are depreciated on the basis of cost, years of use, and salvage value, taking death loss and sales into account. For the 1928–1930 period salvage value of slaughter bulls was calculated at $80 and of serviceable bulls $110. The investment in bulls is computed from the bull inventory, which takes into account cost, appreciation, and depreciation, and presents the average value for all ages.

Average Bull Costs

Carrying cost per head (cost per cow unit x 1½)		$22.32
Depreciation and death loss per head		11.53
Bull maintenance cost per head		$33.85
Bull cost per breeding cow	$1.79	
Bull cost per calf branded	2.80	
Average investment per head (all ages)	122.76	

The majority of ranches run from 21 to 37 breeding cows per bull of serviceable age, with an average of 24. Twenty-two per cent of the bulls carried on the ranches are young bulls being grown out for later service. Ranchers who supply one good serviceable bull to approximately 25 breeding cows get the best calf crops. Some outfits have more bulls than necessary, counting old bulls unfit for efficient service; others have far too few of serviceable age and condition for best results. Approximately 10% of the bulls of serviceable age were seven years old or over. Bull maintenance cost per head on most ranches runs from $24 to $38, with an average of $33.85. This cost is dependent upon original cost, carrying cost, depreciation and death loss.

On most ranches bull cost per breeding cow runs from $1 to $2.50, the average being $1.79. Bull cost per calf branded ranges from $1.50 to $3.24 on the majority of ranches, the average being $2.80. It is practically impossible to establish definite causes for variations in bull cost per cow and bull cost per calf as between different ranches, since the cattle range in common and stockmen who do not provide enough bulls get the benefit of bulls supplied by others.

Bull cost is an expensive item on a cattle ranch. The bull herd requires constant attention to keep it in maximum working order. For best results bull replacements should be made frequently. Frequent bull replacements accomplish the following purposes which affect maximum service.

1. The bulls are easier to handle and become accustomed to the range quickly.
2. There is a better distribution of young and old bulls for range and pasture breeding.
3. The percentage of death loss is reduced.
4. A smaller outlay of money at one time is required.

A sufficient number of good bulls of the right type for range use are

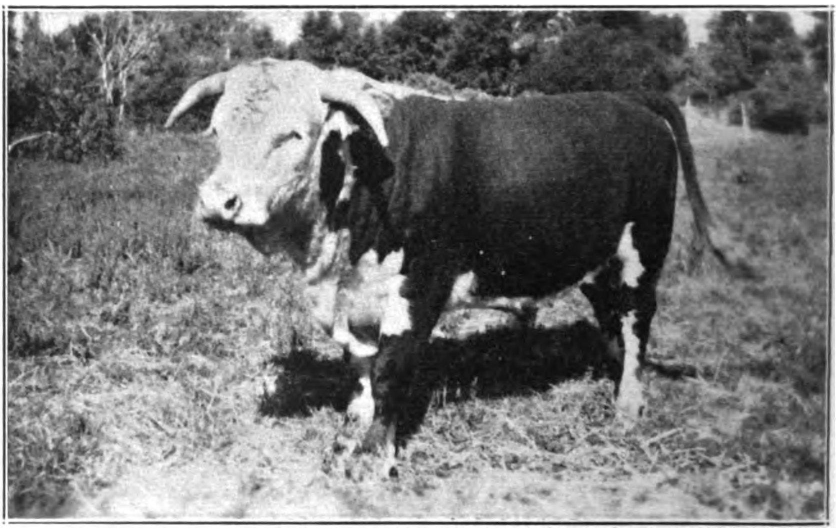


Fig. 14. A Good Range Bull.

essential for the efficient production of cattle. A good point to remember is that the bulls are half the herd.

DEATH LOSS

Death loss is the percentage of cattle dead or missing during the year, computed by dividing the number missing by the number of cattle on the ranch a full year (occupancy head). For the period under study death loss among all cattle on the twenty ranches averaged 3.10 per cent. Among cattle other than bulls the average was 3.04 per cent. Loss among bulls ranged from no death loss to 13.6 per cent, the average being 5.23 per cent. The big death losses occurred among old bulls and young bulls not thoroughly acclimated. The death loss among seasoned bulls from three to six years old is apparently less than that among other stock cattle.

Death loss is largely attributed to poor range, poisonous plants, disease, predatory animals, and theft. On poor ranges death loss is invariably high and it is difficult if not impossible to remedy. Cattle

occasionally are wintered well and turned out on the range in excellent condition, only to come back in the fall poorer than when they left and fewer in numbers.

Poisonous plants in some districts practically prohibit economic cattle production. On the higher elevations of the Ruby Mountains larkspur takes a heavy toll annually.

Predatory animals, with respect to cattle losses, are pretty well controlled. Proof of this is established by the fact that in districts well fortified against losses from other causes the death loss is low and can easily be attributed to natural causes.

Loss attributed to theft is a severe handicap to stockmen in certain sections of the country. One outfit, during one year, suffered a nine per cent death loss when three per cent should normally cover the

Fig. 15. Range Bulls in the Feed Lot.

conditions under which it operated. This percentage only accounted for branded stuff. The calf crop was far under average and this was laid to the theft of a good many unbranded calves. In numerous instances cows were gathered with big bags and no calf. Quite often cow hands report finding evidence that an animal had been slaughtered on the range. Occasionally they have identified the animal because the thieves have left the hide on the range with the offal. Fortunately severe outbreaks of theft are periodical. When this condition becomes critical in a district all hands are on the lookout and the thieves leave or quiet down for a while.

Death loss fluctuates somewhat due to the method of running and sale of the cattle. Some ranchers hold their old cows in the field in the spring, nurse them along on good feed through the summer, and dispose of them all regardless of condition before winter sets in again. This practice cuts down death loss, though its advisability is dependent upon available ranch pasture, and the difficulty in gathering off the range.

Trying to get the last year of service out of an old bull on the range is false economy. The death loss among old bulls seven years and over ran as high as 27.5 per cent on two different ranches. The average

death loss among all bulls seven years and over is 16.5 per cent. Old bulls must be disposed of from time to time. It is better to sell them than lose them on the range. A good time to sell bulls carrying age is when prices are high even though they have another year or so of service in them.

The average cowman readily understands these situations and appreciates that there is considerable expense encountered in taking the

Fig. 16. A Steer Killed by Larkspur.

chances set forth above, but few if any actually realize the price they have paid. Instances of this nature are not common, yet they are on the whole so frequent that almost every stockman of consequence has had at least one costly experience with imported bulls or old timers.

CALF CROP

Calf crop percentage is found by dividing the number of calves branded during the year by the number of breeding cows on the ranch a full year.

		Majority of Ranches			
	Low	From	To	High	Average
Calf crop per cent	50.53	56.92	72.43	84.14	63.92

There are many causes for the differences between good and poor calf crops, and in many cases it is very difficult if not impossible to overcome them. Important factors that cause low calf crop are:

1. Inadequate supply of serviceable bulls.
2. Bulls not acclimated, in poor condition, unevenly distributed, and often too old.
3. No provision made to supply fresh bulls for service when cattle are gathered.

4. Cows not in thrifty breeding condition due to poor range, insufficient balanced winter rations, or a combination of both.
5. Heifers bred too soon, causing them in many cases to skip a year before calving again.
6. Big calves allowed to suck the cows, often causing the cow to lose her next calf, or run down in flesh and pass a year.
7. Abortions and genital diseases.
8. Losses due to lack of care and shelter, especially true among newborn calves in the winter months.
9. Keeping breeding stock, calves, and mixed classes of cattle in the same pasture.

On some ranches there is considerable loss of calves during the winter months. Strictly wild hay ranches, with little shelter, experience the most trouble along this line. The problem is not easily solved. Calves dropped after November suffer loss due to rigorous weather on large unprotected areas. The straight wild hay crop matures early and it is difficult to prevent its going into the stack extremely dry. Such feed is not conducive to milk flow, and the fall and winter calves often have

Fig. 17. Old Cows Held on Pasture.

a hard time existing. It is surprising to note the cold weather a calf will stand if its mother has a good milk flow. Controlled breeding would possibly correct the trouble but on this type of ranch the cows are often on the range nine months out of the year and the practice would have to be initiated by all cattlemen in the section, which constitutes something of a problem.

Providing supplemental feeds and shelter work out very well in some instances. Ranchers who have roomy sheds, barns, or plenty of brush shelter and considerable alfalfa hay have calves born the year round with excellent results. The wild hay ranch, lacking such facilities, necessarily works to cope with the problem by erecting sheds and providing purchased concentrates such as oil cake to make better provision for winter calves. Cows ranging out nine months of the year are wild and hard to handle in and out of barns or sheds. It undoubtedly takes several years of this sort of handling to get the practice to a point where it more than pays for the added cost. In years when the rancher is compelled to purchase extra feeds the transaction can be counted on to cut deeply into his revenue.

On ranches without brush or natural shelter, where considerable

tame hay is grown, some operators have large cow barns for handling calfy cows. Not infrequently this type of ranch runs the cattle on the open range except in severe weather. During cold stormy spells the calfy cows and weak stuff are brought to the ranch for feed and shelter. This practice increases calf crop percentage and lowers death loss.

Calf crop is a vital factor in the cattle business. Too often cattlemen go on producing without paying any great amount of attention to this important item and within a few years, unless they have a very low running cost, financial embarrassment and failure are certain to follow.

THE PRODUCTION COST OF CATTLE

Cattle production costs are dependent on four main factors:

Carrying Cost Per Cow Unit.
Bull Cost Per Breeding Cow.
The Percentage of Death Loss.
The Percentage of Calf Crop.

Cow maintenance cost is the total of carrying cost, bull cost, and death loss per breeding cow. Calf cost is computed by dividing cow maintenance cost by calf crop percentage, since the calves produced carry the cost of all breeding cows. Seasonal breeding is not practiced. Calves are dropped the year round. Accordingly at the end of the year calves produced during the year average six months of age.

Average Costs

Cow Maintenance Cost:	
Carrying cost per cow	$14.88
Bull cost per cow	1.79
Death loss per cow (3.04% x $50)	1.52
Total cow maintenance cost	$18.19

Maintenance cost $18.19 divided by calf crop 63.92% equals the cost of a calf at six months, $28.46.

The production cost of older animals consists of calf cost plus carrying cost and death loss.

The majority of ranches produce six months calves at from $24 to $33, the average being $28.46.

Two-year-olds are produced by the majority of ranches within a cost range of $42 to $60, the average being $49.10.

The initial calf cost is a very important item in cattle production. By noting the difference in calf crop percentages with practically the same cow maintenance cost, one may readily see the marked influence this factor has on the production cost of a calf. For instance, ranches K and Q have practically the same cow maintenance cost. However, a 20 per cent difference in calf crop gives a difference of over $7 in the cost of a calf.

Providing death loss and bull costs are normal, low calf costs are the result of low carrying cost coupled with a medium to high calf crop, or a fairly high carrying cost coupled with a high calf crop. The ideal for each ranch is to hold carrying cost, death loss and bull cost as low as possible and still get a good calf crop.

Chart Number 11

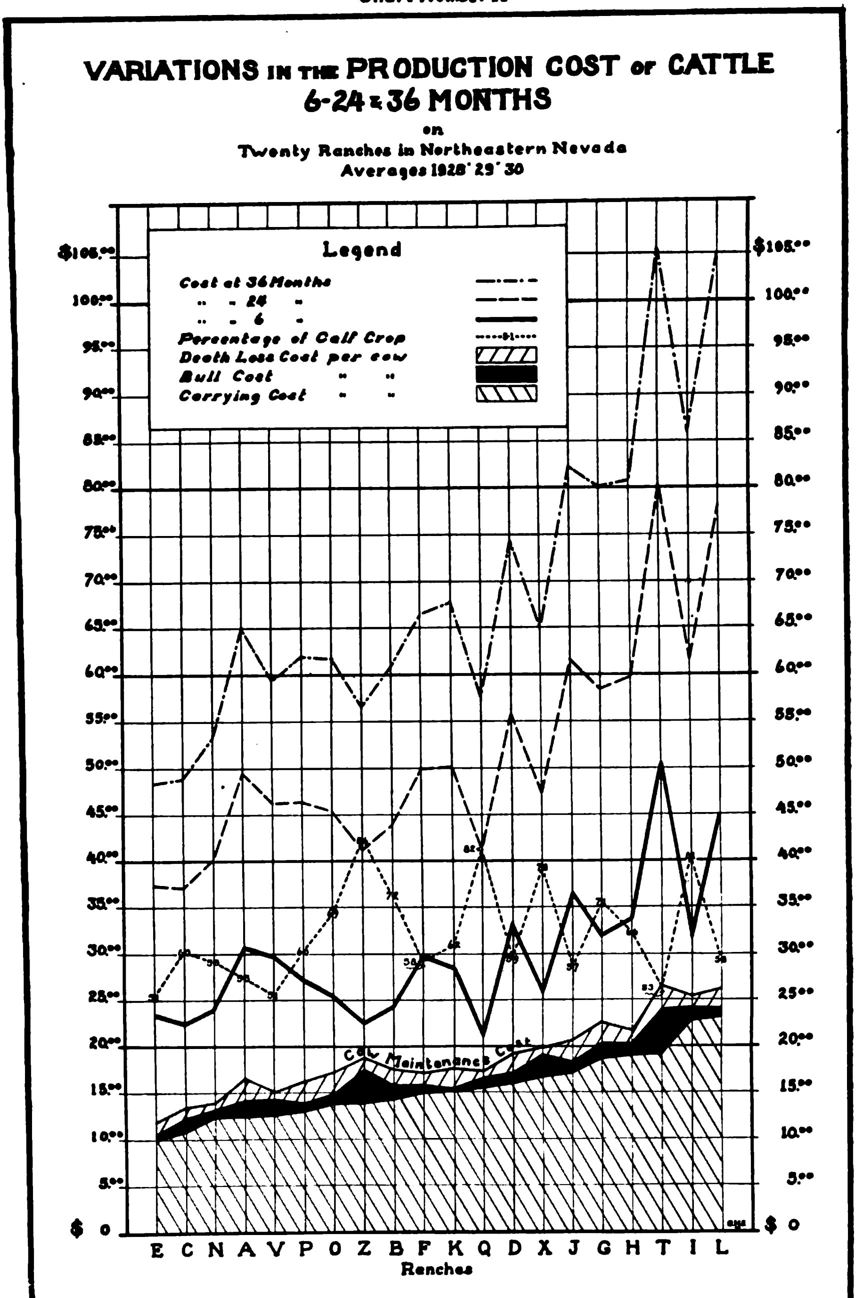


TABLE NO. 11

Variations in Production Costs

Ranch	Carrying cost	Bull cost	Death loss cost	Cow maintenance cost	Calf crop per cent	Cost at 6 mo.	Cost at 24 mo.	Cost at 36 mo.
E	$9.97	$0.60	$1.29	$11.86	50.53	$23.47	$37.27	$48.39
C	10.74	1.53	1.21	13.48	60.29	22.36	37.04	48.86
N	12.33	.88	.71	13.92	58.18	23.93	40.14	53.16
A	12.42	1.80	2.55	16.77	54.90	30.55	49.50	64.92
V	12.57	1.85	.70	15.12	51.06	29.61	46.22	59.37
P	13.07	94	2.30	16.31	60.25	27.07	46.30	61.95
O	13.78	1.17	2.38	17.33	68.72	25.21	45.33	61.75
Z	13.97	3.73	1.17	18.87	84.14	22.43	41.22	56.40
B	14.10	1.63	1.78	17.51	72.43	24.18	43.92	61.00
F	14.91	.95	1.28	17.14	58.06	29.52	49.94	66.41
K	15.02	.36	2.16	17.54	61.74	28.41	50.12	67.79
Q	15.40	1.13	.81	17.34	82.29	21.07	41.25	57.50
D	15.84	1.34	2.10	19.28	58.72	32.83	55.81	74.49
X	16.52	2.60	.85	19.97	78.16	25.55	47.32	64.86
J	17.01	1.34	2.35	20.70	56.92	36.37	61.50	82.06
G	18.69	1.75	2.08	22.52	70.88	31.77	58.42	80.11
H	18.92	1.27	1.44	21.63	64.25	33.66	59.67	80.72
T	19.15	4.81	2.49	26.45	52.63	50.26	80.67	105.50
I	22.65	1.65	1.03	25.33	80.67	31.40	61.45	85.72
L	23.02	1.06	2.09	26.19	58.22	44.95	78.16	105.17
Average	$14.88	$1.79	$1.52	$18.19	63.92	$28.46	$49.10	$65.82

TABLE NO. 12

Average Production Costs

Age	Cost per head	Lbs. per head	Cost per lb.
6 months	$28.46	370	$0.077
12 months	34.64	525	.066
15 months	37.73	605	.0624
18 months	40.82	685	.0596
21 months	44.96	800	.0562
24 months	49.10	930	.0528
27 months	53.25	1,000	.0533
30 months	57.39	1,040	.0552
36 months	65.82	1,100	.0598

Table No. 12 presents the average production cost, average weight and average cost per pound for the different ages of cattle. The age to sell cattle is when the animal carries the most weight for the least production cost per pound. This study indicates that the production cost per pound on the average ranch is least at 24 months of age.

However, this conclusion is not applicable to individual outfits because variation in range conditions, carrying cost, calf crop and weights are reflected in cost per pound. A rancher should study his individual set-up relative to costs and weights and thereby determine the best selling age suited to his operation.

When it is realized that these costs do not include investment interest a comparison with average market prices shows the narrow margin on which such cattle producers operate.

GENERAL DISCUSSION AND CONCLUSIONS

Under the separate accounts, figures and factors affecting particular costs are presented. A general discussion of interrelated ranch accounts follows:

Size and organization of the cattle outfit have a great influence on costs. Almost without exception outfits running under 400 head, even if properly balanced in land and cattle, have a high carrying cost. Volume production counts in the cattle business, as in any other. The management and organization, size and location of the ranch and number of cattle should be planned to constitute a balanced operation.

Such a balanced organization can be perfected with a medium-sized or a very large herd of cattle. With the larger outfits the complete management need not be centered in one man as long as there is sufficient interest and understanding concerning the responsibility of those in charge. Economy, efficiency, and volume production can be accomplished with multiple management where one partner takes charge of the ranch, another looks after the cattle, a third the books and business transactions. The maximum limit on the number of cattle for efficient production is dependent upon management and the service capacity of the organization.

Scattered properties are a handicap and should be avoided if possible. A cattle ranch cannot endure long if loose management, haphazard methods, and indifference are allowed to creep in. Old time cattle ranches that weathered the storms of high costs and low prices during

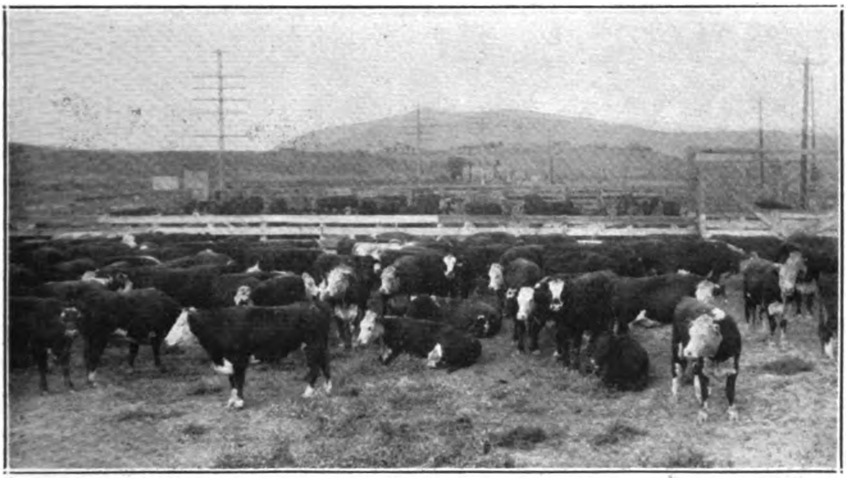


Fig. 18. Beef Steers Enroute to Market.

the period from 1921 to 1927 can be counted on to have fairly substantial organizations.

A low or high production cost is not necessarily a reflection of good or bad management. For example an exceptionally good manager operating a nicely balanced ranch organization in good range country obviously can produce cattle for much less than he could with a poor range. A poor range or one with a short season of range utilization exerts an unbalancing effect upon the efficiency of producing cattle. This condition is reflected in higher production costs. Such a range with a short grazing season necessitates providing more expensive forage, such as privately owned pastures or leased areas; or it forces the early utilization of the cut-over hay lands when they would otherwise be held in reserve for late fall and winter forage. When the grazing resources become exhausted the feeding of hand cured forage must be started. In either case the cost of maintaining and producing all classes of cattle on the ranch increases, due to added grazing costs or the long hand feeding season and the amount of expensive feed consumed.

In one locality high hay production cost may be offset by the small amount required per cow unit. In the end the carrying cost may be well in line for economical production. This principle applies to many of the accounts which contribute to production cost. Operators are prone to become most interested and efficient in the department to which the ranch best lends itself. The man on a good hay ranch is proud of it, gets a good yield and produces it very efficiently. While his attentions are centered on one department, another is apt to be neglected. A ranch manager is rarely equally efficient in all departments of the ranch. He takes the lead in the most important work at hand and sometimes during busy seasons puts off some other work, or lets it slide without supervision. Invariably the result is costly.

Calf crop, death loss, weight and condition of the cattle are directly

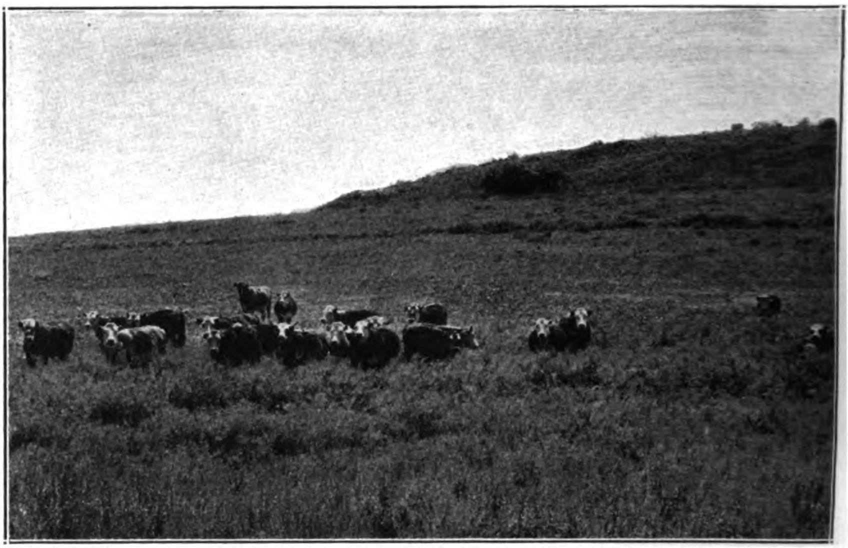


Fig. 19. Good Cattle Range.

dependent upon the way the cattle are handled and cared for. It is easy to understand that if the calf crop can be increased without materially adding to carrying cost, this will speed up production and increase revenue. With the average calf cost $28.46, it is clearly obvious that heavy losses are often sustained in the sale of calves or of good breeding cows in calf. With few exceptions ranchers do not consider the costs represented in unborn calves carried by good brood cows which are disposed of in the beef herd. Low cow unit carrying costs and good calf crops are essential to success in the production and sale of calves.

More feed and better care are conducive to higher calf crops, heavier cattle, lower death loss, and greater gross receipts, but the added cost necessary to effect the change should be less than the additional revenue. Seasons vary, available feed supply changes, and each year practically every ranch is confronted with a different problem. Under these conditions definite conclusions with positive recommendations

would be subject to question. Cattle fed all they are capable of consuming will eat their heads off; on the other hand, starving a bunch of cattle through on poor range and scanty winter rations is likewise unprofitable. A happy medium must be reached for each ranch which will yield the best return for the money.

As shown on Charts Nos. 8 and 10 the largest item entering into carrying cost is feed. Feed cost is largely dependent upon the amount of hand feeds and the grazing expense required to keep cattle in reasonably good condition. As feed cost increases carrying cost also goes up, and higher calf crop, better quality and heavier cattle are necessary to offset it. Material increases in carrying cost are extremely difficult to overcome. With grazing expense and other conditions equal, the amount of hand feeds given range cattle should be held down to the minimum quantity that will carry them through the winter months in reasonably thrifty condition.

It is significant to note on Chart No. 11 that as carrying cost goes up

Fig. 20. Poor Cattle Range.

cattle production costs increase, in spite of higher calf crop. Death loss and bull costs show less variation and influence production costs to a correspondingly lesser degree.

Calf crop percentage has its greatest effect on the first cost of the calf. A comparison of Ranches E and Q on Chart No. 11 illustrates this point. Ranch E has the lowest carrying cost of the entire group, coupled with the lowest calf crop. Ranch Q has a carrying cost above the average and a high calf crop. Their production cost figures follow:

	E	*Q*
Carrying cost	$9.07	$15.40
Bull cost	.60	1.13
Death loss cost	1.29	.81
Cow maintenance cost	$11.86	$17.34
Calf crop	50.53%	82.29%
Production cost at 6 months	$23.47	$21.07
Production cost at 24 months	37.27	41.25
Production cost at 36 months	48.39	57.50

After the first cost of the calf, carrying cost is the important factor affecting the production cost of older animals. Under these conditions

it is not surprising that in actual practice Ranch E has found it most profitable to sell mature cattle, while Ranch Q makes its best profit selling calves.

Accordingly it is evident that carrying cost has a greater influence on production cost of mature cattle than calf crop or any other factor. In other words, a low carrying cost is first in importance in range cattle production.

Natural advantages in one locality are often offset by disadvantages which balance costs. One ranch may have an extremely low operating cost, in which case it often has a low calf crop or high death loss, which increases production cost. The cattle produced are likely to be light-weight or scrubby, resulting in decreased revenue. Another outfit with a very different set of conditions may have a fairly high operation cost offset by a good calf crop, low death loss, and the production of heavy cattle of good quality.

Each operator, by experience, has to determine the management practices best suited to his ranch. That is undoubtedly why cattle ranches generally run behind when managers are changed frequently. What will work efficiently on one place is often out of the question on another, and to make blanket suggestions for all cattle ranches without reservations is indeed hazardous. The best that can be done is to present methods which have been found successful under stipulated conditions. Cattlemen can then put them in practice if their local conditions permit.

APPENDIX

Costs herein cover the years 1928, 1929 and 1930. High wages and peak commodity prices prevailed. High operation costs ruled during the three years but demand and prices for beef cattle were good. In 1928 the top price f. o. b. loading point was eleven cents for range steers and nine cents for cows. In 1929 it was nine cents for steers and seven cents for cows, and in 1930, seven cents for steers and five cents for cows.

Articles and commodities consumed are charged at purchase price or production cost. Depreciation is charged on items of inventory value.

Some price examples follow, which picture conditions during this period:

1. Labor (Ranch wages, board and lodging found)—

Common ranch hands	$50.00 to $60.00 per month
Irrigators	60.00 to 75.00 per month
Top cow hands	60.00 to 75.00 per month
Hay stackers	3.00 to 4.00 per day
Hay teamsters	2.50 to 3.50 per day

2. Management Salary—Unpaid ranch managers are allowed a salary comparable with paid managers holding similar positions. The scale for ranch managers follows:

Under 500 head of cattle	$1,440.00
500– 600 head of cattle	1,800.00
600– 900 head of cattle	2,160.00
900–1,400 head of cattle	2,520.00
1,400–1,900 head of cattle	2,880.00
1,900–2,400 head of cattle	3,240.00

3. Farm Machinery—

Mowing machines	$100.00–$110.00
Sulky rakes	75.00– 90.00
Buck rakes	85.00– 120.00
Spring tooth cultivators	140.00– 160.00
Light walking plows	30.00– 40.00
Manure spreaders	185.00– 200.00
Grain binders	225.00– 285.00

Hardware and repair parts proportionately in line.

4. Expendable Supply Costs—

Flour	$3.45–$4.00 per cwt.
Cane sugar	6.00– 8.50 per cwt.
Canned goods	2.50– 3.50 per case
Beans	7.00– 9.25 per cwt.
Coffee	.33– .50 per lb.

5. Feed—*Purchased*—

Hay	$8.00–$12.00 per ton in the stack
Cottonseed cake	45.00– 65.00 per ton
Grain	1.50– 3.00 per cwt.

Ranch Produced—

Hay......from $3.74 to $9.34 per ton, averaging $5.63 per ton

Grain...cost figured from similar data applied to Nevada cattle ranch conditions. The price is $1.50 per cwt.

6. CATTLE—Cattle prices were established on the basis of the first year's cost data. These values are held constant through the study for the purpose of computing production costs. Heifers are considered mature at two years of age. They are beginning to produce and earn; hence all mature cows are held at a constant figure.

6 months calf	$28.50
Yearlings	34.50
2-year-old steers and mature cows	50.00
30 months stock steers	58.00
36 months beef steers	67.00

7. OTHER LIVESTOCK are valued at production costs computed from similar cost data applied to Nevada cattle ranch conditions where they are raised in small numbers considered sufficient to facilitate better operation of the ranch and not as a major enterprise.

Horses and Mules	Mature stock, 3 years and up	$50.00
	2-year-olds	40.00
	Yearlings	26.75
	Suckling colts	20.00
	Stallions and jacks	200.00
Sheep	Mature ewes	11.25
	Yearlings	8.75
	Lambs	6.25
	Bucks	15.00
Hogs	Brood sows	8.40
	Shoats	5.60
	Pigs	2.80
	Boars	12.60
Poultry	Chickens and ducks	.75
	Turkeys and geese	2.75

8. RANCH PRODUCED FOOD SUPPLIES actually consumed during the year are charged at production cost, computed without interest from similar cost data, applied to Nevada cattle ranch conditions.

Poultry and Dairy Produce—

Eggs	$0.30 per dozen
Whole milk	.10 per gallon
Skim milk	.02 per gallon
Chickens and ducks	.75 each
Turkeys and geese	2.75 each

Orchard and Garden Produce—

Potatoes	$1.50 per cwt.
Apples	1.25 per cwt.
Root vegetables	3.00 per cwt.
Leaf vegetables	4.50 per cwt.

Meats—	Live weight	Dressed weight
Veal	$0.07	$0.12
Beef	.06	.12
Pork	.07	.10
Lamb	.085	.175
Yearling sheep	.09	.18

3